CHAPTER D.3
CHANGES IN LOUISIANA'S SHORELINE: 1855–2002

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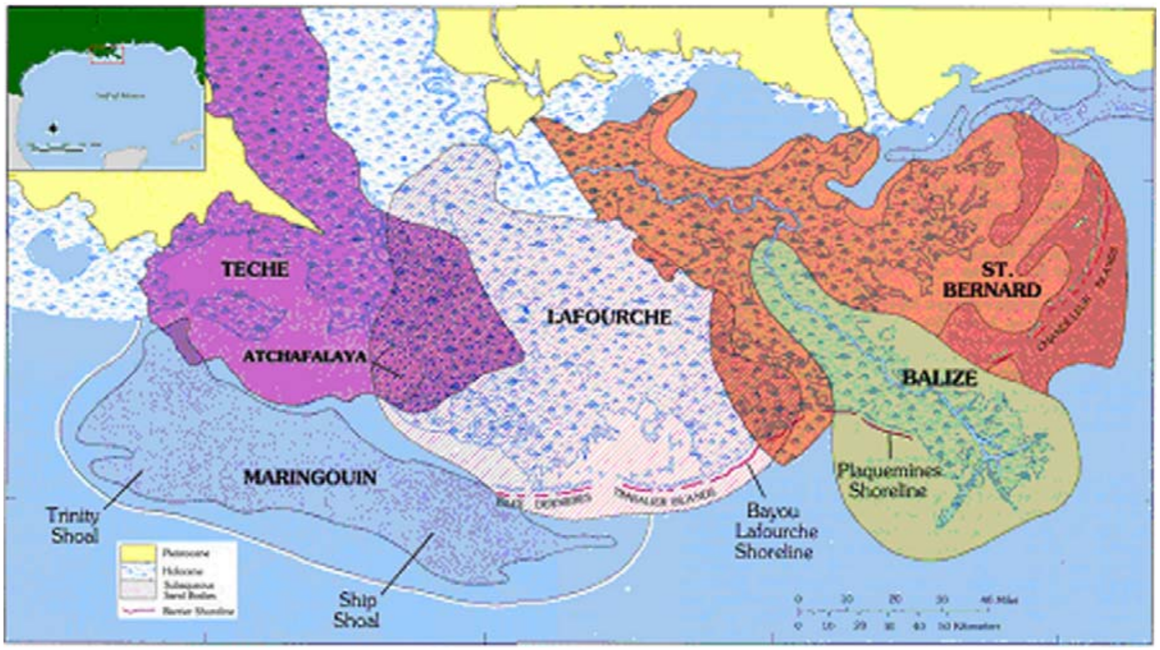
3.1 Summary

Louisiana's Gulf shoreline is eroding. Over the last century, the rate of erosion has progressively increased, threatening the health of coastal Louisiana. In order to provide a basis for planning the restoration of Louisiana's Gulf shoreline, this chapter reviews previous erosion studies and provides an assessment of shoreline change. Using historical maps and aerial photography, the patterns and rates of shoreline change are mapped. The Gulf shoreline is divided into 31 reaches based on the geomorphology, change trends, existence of man-made structures, and/or a combination of these factors. The average rate of long-term (greater than 100 years) shoreline change is -19.9 ft/yr. The average short-term (less than 30 years) rate of shoreline change is 30.9 ft/yr. The highest rates of erosion are found in the erosional shadows of hard coastal structures, such as navigation jetties, seawalls, and breakwaters. Beach nourishment, dune construction, and backbarrier marsh creation are the only project types that built new land and reversed Gulf shoreline erosion.

3.2 Introduction

Modern Mississippi River delta building processes and the oceanographic climate of the Gulf of Mexico control the natural patterns of shoreline change in Louisiana. Since sea level stabilized at its current position at approximately the end of the last Ice Age, the Mississippi River has built its delta plain by a process of distributary channel or delta complex switching (Fisk 1944; Kolb and Van Lopik 1958; Frazier 1967). The distributary switching process produces abandoned and active delta complexes within the larger Mississippi River Deltaic Plain. Active deltas are a characterized by shoreline progradation as found at the mouth of the Mississippi and Atchafalaya Rivers (Russell et al. 1936; Coleman 1988; Robert 1997). The Holocene Mississippi River Deltaic Plain is comprised of six delta complexes, four of which are abandoned with transgressive barrier shorelines. These include the Maringouin, Teche, St. Bernard, and Lafourche. Two delta complexes are active: the Modern and Atchafalaya (Penland et al. 1981; Roberts 1998; Figure D.3- 1). West of the Mississippi River Deltaic Plain lies the Chenier Plain. Here too shoreline changes are linked to the delta complex switching process

(Howe et al. 1935; Gould and McFarlan 1959; Penland and Suter 1989; Roberts 1998; Figure D.3- 2). When the Mississippi River is discharging into the western region of its delta plain, Chenier Plain mudflats prograde, and the shoreline advances seaward (Wells and Kemp 1981). When the Mississippi River discharges into the eastern region of its delta plain, the Chenier Plain shoreline erodes landward, forming individual chenier ridges (Hoyt 1969). Superimposed on this natural pattern of shoreline development in Louisiana are man's activities to support the economic development and management of the coast. Flood control and navigation have altered the hydrology of the Mississippi River, severely disrupting and modifying sediment delivery to Louisiana's coast.



Two delta complexes are active, the Atchafalaya and Modern (Belize). Four delta complexes are abandoned and surrounded by transgressive or erosional barrier shoreline and inner shelf shoal systems (Penland et al. 1988). From youngest to oldest, these barrier systems include the Plaquemines shoreline, the Bayou Lafourche shoreline, the Isles Dernieres shoreline, the Chandeleur Islands shoreline, and the Ship Shoal/Trinity inner

Figure D.3- 1. A map of the six delta complexes within the Holocene Mississippi River delta plain.

Today, Louisiana's coast is experiencing rapid rates of subsidence and relative sea level rise ranging from 1–3 ft per century (Penland et al. 1989; Penland and Ramsey 1990). Storms drive high wave energy and overwash events that erode and breach the barrier shoreline. Dune systems are thus reduced to lower relief, eroded washover features. Coastal navigation, protection, and restoration projects are damaged and in some cases destroyed by these Gulf of Mexico storms. During fair-weather conditions, beaches recover, breaches close, and dunes rebuild—but never to their pre-storm condition. In a storm's aftermath, navigation projects typically undergo emergency maintenance dredging. Localized coastal protection and restoration projects are rebuilt and in some cases re-engineered only to await the next storm's impact. The combination of the Mississippi River Delta and Chenier Plain building process and man's attempt to manage and control this natural system has failed to produce the desired benefits, resulting in the highest rates and largest magnitude of coastal erosional and wetland loss in America

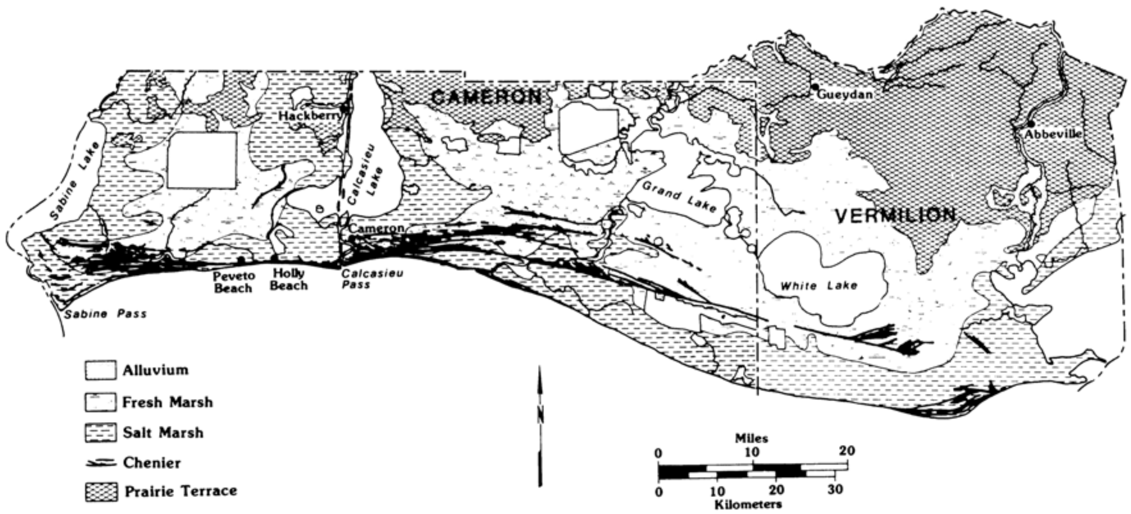


Figure D.3- 2. A geologic map depicting the geomorphology of the Mississippi River Chenier Plain in western Louisiana (Penland et al. 1990).

3.3 Previous Coastal Erosion Research

This section presents a history of shoreline change research in Louisiana.

3.3.1 U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (USACE) is one of the first government agencies to report on coastal erosion in Louisiana. Since the 1930s, the USACE has conducted several regional planning studies to facilitate the design of shoreline erosion control projects. The USACE's first detailed coastal erosion study was conducted for Grand Isle in 1936; subsequent coastal erosion reports were issued for Grand Isle in 1955, 1962, 1972, and 1980 (U.S. Army Corps of Engineers 1936, 1978, 1980). All of these investigations analyzed erosion conditions along the coast, reviewed the causative processes, and proposed and analyzed several designs for beach protection. The most comprehensive study of Grand Isle was the 1980 USACE report, which contains extensive information on coastal erosion, coastal processes, sand resources, and designs for the USACE beach erosion and hurricane protection project built in 1984. Combe and Soileau (1987) reported on the successful performance of this hurricane protection and beach nourishment project at Grand Isle during and after Hurricanes Danny, Elena, and Juan.

Another series of USACE studies concentrated on coastal erosion in the area between Raccoon Point and Belle Pass, which includes the Isles Dernieres and the Timbalier Islands (Peyronnin 1962). It was reported that at Belle Pass the coast eroded at a rate of 95 ft/yr between 1890 and 1960. The Timbalier Islands were reported to be eroding at the rate of 30–90 ft/yr, and the Isles Dernieres at a rate of 24–30 ft/yr. Peyronnin (1962) concluded that the barrier islands between Raccoon Point and Belle Pass are important defenses against wave and storm impact on the mainland and recommended beach nourishment as the most viable remedial action. The

USACE updated the 1962 Raccoon Point-to-Belle Pass report in 1975 (U.S. Army Corps of Engineers 1975a). The shoreline change history was updated from 1959 to 1969, and this report documented accelerations in beach erosion. This report also evaluated a variety of erosion control scenarios including no action, beach nourishment, barrier restoration, and building rock seawalls. The recommended plan consisted of beach nourishment and the construction of earthen dikes designed to close existing breaches in the barrier islands, as well as a maintenance program to prevent future breaches. Another USACE (1975b) report indicated that, if left unprotected, the Isles Dernieres and Timbalier Islands would continue to deteriorate and wetland loss could approach over 40,000 acres over the next 50 years.

In 1961 the USACE reported on the navigation jetties constructed at Sabine and Calcasieu Passes in the Chenier Plain of west Louisiana. These navigation structures extended seaward and blocked longshore sediment transport to the west. Sediments accumulated on the east side or updrift side of the Sabine Pass and Calcasieu Pass jetties, with an erosional shadow produced on the west or downdrift side of these structures. The Sabine Pass jetties were built between 1883 and 1885 with east and west completion lengths of 25,000 ft and 22,000 ft respectively (Morton 1975). The construction of the east jetty at Calcasieu Pass began in 1893, and the west jetty began in 1896 (USACE 1961). Over the next 45 years, the Calcasieu jetties were modified, and by 1942, the length of the east and west jetties reached 10,500 ft. and 8,200 ft, respectively. The Calcasieu River jetties produced chronic erosion to the west along LA Hwy 82 between Holly and Peveto Beaches. In response to this erosion, the Louisiana Department of Transportation and Development built a three mile long geotextile revetment of Gobi Blocks (Dement 1977).

In 1971, the USACE produced a report on the shoreline erosion problems from Holly Beach to Peveto Beach along Highway 82 (U.S. Army Corps of Engineers 1971). The erosional shadow of the Calcasieu River jetties had cut off the longshore transport of sediment to the west, causing erosion of Holly Beach and the area further west. The long-term erosion was measured at -1.0 ft/yr for Holly Beach and -5.1 ft/yr for Highway 82 to the west between 1883 and 1968. Between 1957 and 1968, the rate of shoreline erosion accelerated between Holly Beach and Highway 82 to -16.1 ft/yr and -11.3 ft/yr, respectively. This report provided information on coastal processes and the economic feasibility of providing improvements to prevent erosion of the shoreline at Holly Beach and vicinity.

The USACE's first comprehensive inventory of the coastal erosion problems in Louisiana was part of the National Shoreline Study. This study examined the extent and nature of shoreline erosion and culminated in the publication of a series of atlases (U.S. Army Corps of Engineers 1971). This atlas identified the physical characteristics of Louisiana's shoreline, historical changes, ownership, and land use.

3.3.2 Louisiana Attorney General

The first statewide comprehensive study of coastal erosion in Louisiana was conducted by Morgan and Larimore (1957) for the Office of the Attorney General of the State of Louisiana (Morgan 1955). At the time, Louisiana was engaged in a dispute with the federal government about the ownership of offshore oil and gas rights. The study aimed to document the historical trends in coastal change in order to establish the position of the state's 1812 shoreline, which was critical for determining Louisiana's three-mile limit.

The study used historical cartographic data dating back to 1838 from the U.S. Coast and Geodetic Survey (formerly the U.S. Coastal Survey and currently the National Oceanic and Atmospheric Administration [NOAA]), the USGS, the USACE, and the State of Louisiana. Aerial photographs from 1932 and 1954 were analyzed to update the historical maps. Measurements of shoreline change were made at intervals of one minute of longitude from the Texas border to the Mississippi border. For continuity, all maps were enlarged or reduced to a common scale of 1:20,000.

The average rate of shoreline change between 1932 and 1954 for the entire coast of Louisiana was measured at -6.5 ft/yr (Morgan and Larimore 1957; Table D.3-1). The areas of shoreline advance were associated with the Mississippi River mouth and the updrift or eastern sides of the Sabine and Calcasieu jetties, which trap westward moving longshore sediment transport (Figure D.3- 3 and D.3- 4). The shoreline in the vicinity of Mulberry Island and Cheniere Au Tigre was progradational due to Atchafalaya mudflat deposits. Elsewhere, Louisiana's coastline was erosional except for Holly Beach westward past Peveto Beach to Ocean View Beach. In this area, the shoreline was stable.

Table D.3-1 Coast- wide Shoreline Change Rates for Louisiana

Source	Citation	Time Period	Average Rate (ft/yr)	Range (ft/yr)
LA Attorney General	Morgan (1955)	1932-1954	-6.5	-62.0 to > +15.0
	Morgan and Larimore (1957)			
LA Attorney General	Morgan and Morgan (1977)	1954-1969	-17.0	Westward
LA DOTD	Adams et al. (1977)	1954-1969	23.7	-91.5 to Advance[1]
LADNR	van Beek and Meyer-Arendt	1955-1978	-24.3	-8.9 to --35.7
EPA	Penland (1996)	1855-1944	-18.7	-98.4 to Advance[1]
LADNR/USACE[2]	Penland et al (2003)	1855-2002	-19.9	-81.8 to +12.9
LADNR/USACE[2]	Penland et al (2003)	1988-2002	-30.9	-179.4 to +68.4

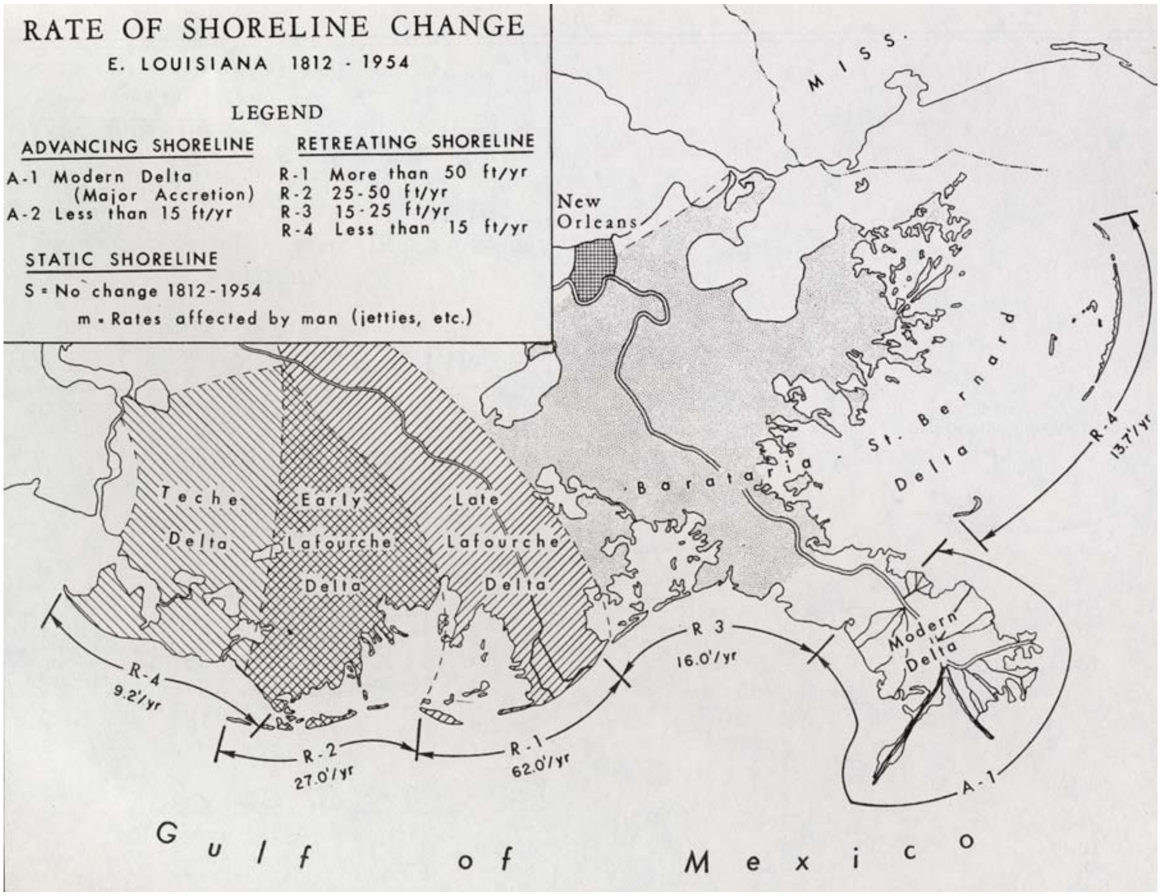


Figure D.3- 3. The first map to depict coast-wide shoreline changes between 1812 and 1954 for the eastern half of Louisiana by Morgan and Larimore (1957) for the Louisiana Attorney General.

The average shoreline erosion rate around the Mississippi River Deltaic Plain was -18.8 ft/yr with a range of > +15.0 ft to -62.0 ft/yr (Figure D.3- 3). The Modern delta complex at the mouth of the Mississippi River was advancing at a rate greater than +15 ft/yr. The most severe erosion was taking place along the Timbalier Islands and the Caminada-Moreau Headland at -62.0 ft/yr. Morgan and Larimore (1957) interpreted the regional variation in shoreline change as a function of geologic control due to natural subsidence. Young deltas subside faster than older ones, and the higher rates of coastal erosion were found on recently abandoned delta complexes.

In the western Chenier Plain, the average rate of shoreline change is -1.0 ft/yr, with a range of -18.5 ft/yr to +11.6 ft/yr (Figure D.3- 4). The most erosional areas were in the central Chenier Plain in the vicinity of the Rockerfeller Wildlife Management Area and Game Refuge at -18.5 ft/yr. Accretion in the eastern Chenier Plain is associated with mudflat progradation from the Atchafalaya River to the east. The two zones of shoreline advance in the western Chenier Plain are associated with the interception of longshore sediment transport at the east flanks of the Sabine Pass and Calcasieu Pass jetties.

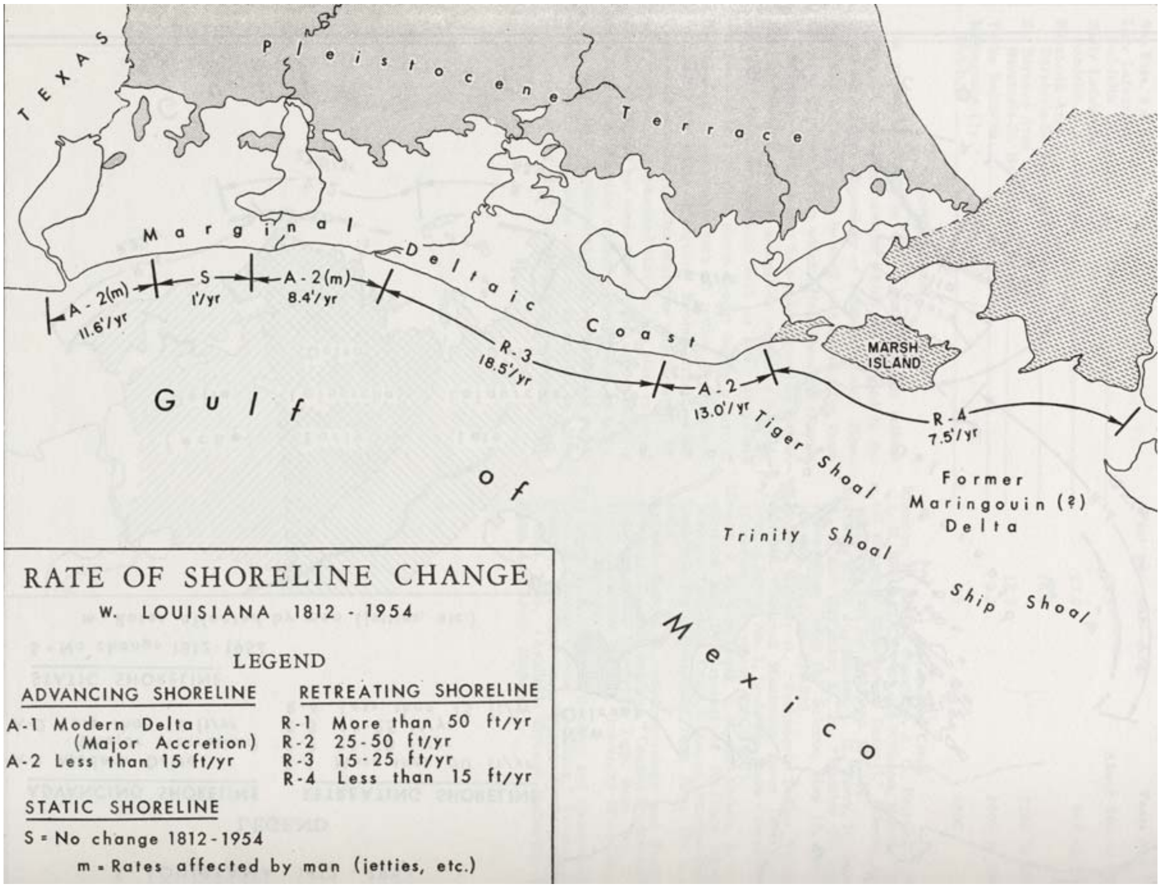
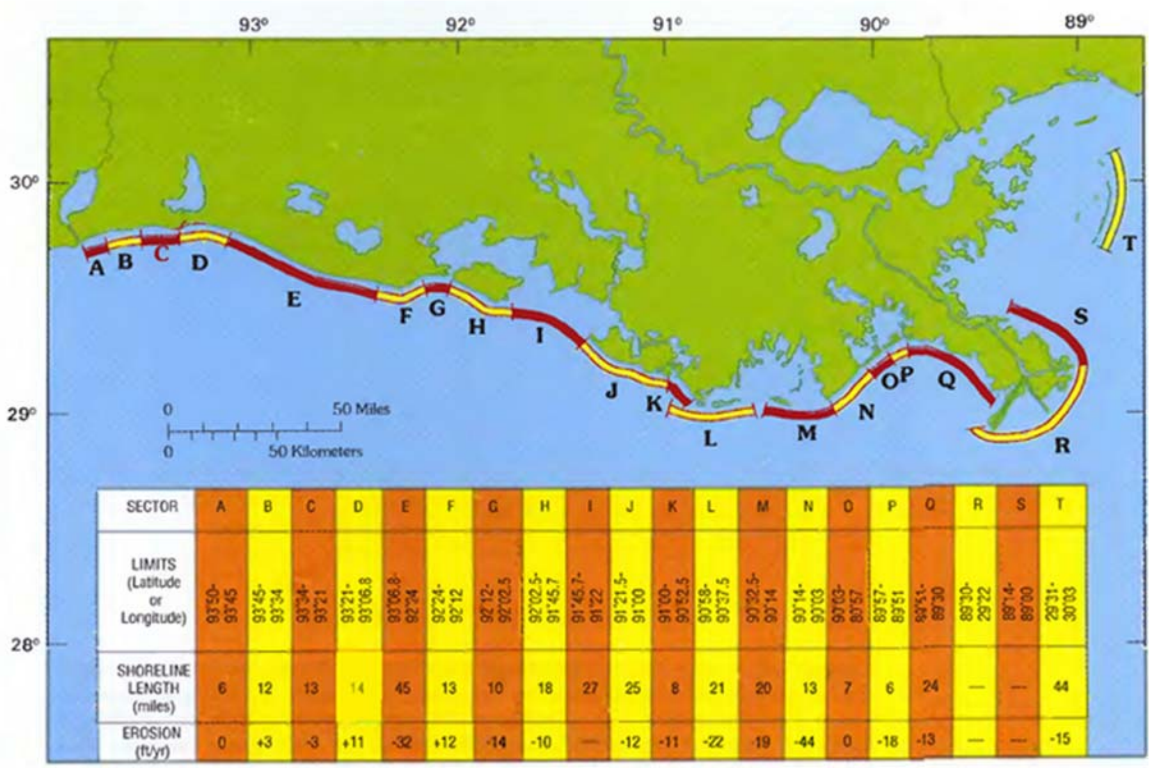


Figure D.3- 4. The first map to depict coast-wide shoreline changes between 1812 and 1954 for the western half of Louisiana by Morgan and Larimore (1957) for the Louisiana Attorney General.

Using updated aerial photography and the same method of analysis; Morgan and Morgan (1983) updated the original study by Morgan and Larimore (1957; Figure D.3- 5). New measurements indicated the rate of coast-wide Louisiana shoreline change had increased from -6.5 ft/yr between 1932 and 1954 to -17.0 ft/yr with a new range of -40.0 ft/yr to >+15.0 ft/yr (Morgan and Morgan 1983; Table D.3-1). The rate of shoreline erosion along the Deltaic Plain decreased from -18.8 ft/yr to -15.7 ft/yr for the 1954 to 1969 time-period, and the Chenier Plain increased from -1.0 ft/yr to -12.0 ft/yr. The areas of substantial increase in shoreline erosion from east to west include the Chandeleur Islands (-13.7 ft/yr to -18 ft/yr), Cheniere Au Tigre (+13.0 ft/yr to -7.9 ft/yr), Rockefeller Refuge Wildlife Management Area and Game Refuge (-18.5 ft/yr to -40.0 ft/yr), and Holly-Peveto Beach (+ 1 ft/yr to -9.0 ft/yr). Morgan and Morgan (1983) explain the acceleration in the erosion of Louisiana's shoreline as a function of man's increasing impacts within the Mississippi River Deltaic and Chenier Plains.



SECTOR	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
LIMITS (Latitude or Longitude)	93°50'-93°45'	93°45'-93°34'	93°34'-93°21'	93°21'-93°06.8'	93°06.8'-92°24'	92°24'-92°12'	92°12'-92°02.5'	92°02.5'-91°45.7'	91°45.7'-91°22'	91°21.5'-91°00'	91°00'-90°52.5'	90°58'-90°37.5'	90°32.5'-90°14'	90°14'-90°03'	90°03'-89°57'	89°57'-89°51'	89°51'-89°30'	89°30'-29°22'	89°14'-89°00'	29°31'-30°03'
SHORELINE LENGTH (miles)	6	12	13	14	45	13	10	18	27	25	8	21	20	13	7	6	24	—	—	44
EROSION (ft/yr)	0	+3	-3	+11	-32	+12	-14	-10	—	-12	-11	-22	-19	-44	0	-18	-13	—	—	-15

This map depicts the natural sectors used to evaluate and update shoreline change on Louisiana's coast by Morgan and Morgan (1983).

Figure D.3- 5. Morgan and Morgan (1983) updated the original Morgan and Larimore (1957) study for the LA Attorney General from 1932 – 1954 to 1932 – 1969.

3.3.3 Louisiana Department of Transportation and Development

In 1978, the LA Department of Transportation and Development's Coastal Resource Programs conducted a coastal erosion inventory for the Gulf shoreline and the major inland bays and lakes (Adams et al. 1978). The average rate of Gulf shoreline change for Louisiana was measured at -23.7 ft/yr between 1954 and 1969. Shoreline change for inland bays and lakes was calculated through 1974, and the average shoreline change trend was erosional. This report by Adams et al. (1978) expanded on Morgan and Larimore (1957) and complemented Morgan and Morgan (1983) by dividing Louisiana's coastal zone into management units. For each management unit the report provided shoreline change information, risk posed by shoreline erosion, and the feasibility of coastal erosion control. The merits of structural and non-structural erosion control were evaluated. A through review of the coastal protection history at Grand Isle between the 1950s and 1970s was provided.

3.3.4 Louisiana Department of Natural Resources

The first comprehensive assessment of Gulf shoreline erosion with coastal restoration guidance by the Louisiana Department of Natural Resources (LADNR) came from the study by van Beek and Meyer-Arendt (1982). This LADNR report assessed the rate of Gulf shoreline change, identified important coastal processes, and developed a coastline erosion severity index. The average rate of Gulf shoreline erosion for Louisiana was measured at -24.3 ft/yr between 1955 and 1978 with a range of -8.9 ft/yr to -35.7 ft/yr (Table D.3-1). The rate of Gulf shoreline erosion surrounding the Mississippi River Deltaic Plain was -31.9 ft/yr and -16.9 ft/yr for the Chenier Plain. This report provided comprehensive land cover maps for 1955 and 1978 and divided Louisiana's shoreline into eight hydraulic units with recommended restoration measures for each. van Beek and Meyer-Arendt (1982) discuss the merits of structural (seawalls and breakwaters) coastal erosion control versus the use of beach nourishment and other hydraulic fill applications. They recommended the use of hydraulic sediment fill, such as beach nourishment, over the use of hard structures. This guidance is based on a review of the poor performance of hard coastal structures in Louisiana. Construction and maintenance costs, compatibility with the natural processes, and the less than desirable benefits of hard coastal structures were all factors in their assessment. Van Beek and Meyer-Arendt (1982) also cautioned that the use of seawalls and breakwaters could in many cases lead to a downdrift erosional shadow with accelerated erosion and potential shoreline breaching.

The first comprehensive study focusing on Louisiana's barrier islands was conducted by the Laboratory for Wetland Soils and Sediments (today the Wetland Biogeochemical Institute) at Louisiana State University between 1978 and 1983 under the sponsorship of NOAA's Office of Coastal Zone Management (Mendelssohn et al. 1986). The analysis of shoreline change was based on two independent sets of data. Changes in Gulf shoreline positions were derived from a series of historical aerial photographs and National Ocean survey T-charts; this produced a high-water line location for every 300 ft of shoreline. The database for the Chandeleur Islands included eight sets of maps and imagery for the 1922–1978 period. The rest of Louisiana's barrier islands were covered by 12 sets of maps and imagery from 1934 to 1978. The second data set was obtained by digitizing the surface area of each barrier island on the Louisiana coast. This method analyzed U.S. Coast and Geodetic Survey and U.S. Geological Survey maps for 1869–1956, together with a series of land cover maps (scale 1:10,000) based on 1979 aerial photography. The results were presented as a time series of variation in island area (Penland and Boyd 1981, 1982). The rate of shoreline erosion for Louisiana's barrier shoreline for this period ranged from -15.4 ft/yr for the Plaquemines shoreline, to -28.9 ft/yr for the Chandeleur Islands shoreline, to -29.5 ft/yr for the Bayou Lafourche shoreline, and -32.1 ft/yr for the Isles Dernieres shoreline.

The first comprehensive engineering study of Louisiana's barrier islands was conducted by T. Baker Smith and Sons, Inc. (TBS) for the LADNR (1997). This engineering study was funded under the auspices of the CWPPRA to develop a set of barrier shoreline protection and restoration plan alternatives for the area between Raccoon Point in the Isles Dernieres and Sandy Point in the Plaquemines shoreline. This study conducted an assessment of the existing physical conditions, environmental resources, and economic resources as the basis of the plan alternative formulation. First, the study predicted future coastal conditions for the area between Raccoon Point and Sandy Point without restoration. Potential impacts to hydraulic conditions (tides, waves, salinity and storms), ecological conditions, and social-economic conditions (fishing, storms, infrastructure, crops) were considered without project conditions. The next step involved identifying existing problems, needs, and potential restoration opportunities. The USGS Louisiana Barrier Island Erosion Study: "Atlas of Shoreline Change in Louisiana from 1853 to 1989" and "Atlas of Seafloor change from 1878 and 1989" provided the foundation for the problem identification step of this analysis (Williams et al. 1992; List et al. 1994). LADNR identified five strategic barrier shoreline restoration alternatives for consideration (LADNR 1997):

1) no action,
2) strategic retreat,
3) fall-back of new barriers,
4) pre-Hurricane Andrew configuration, and
5) historic configurations.

The screening of restoration alternatives was based on four resource criteria: environmental, social, economic, and engineering. An initial screening based on the benefits and impacts to the environmental resources criteria was conduced for these five alternatives. The results of the LADNR barrier island study concluded that no action and strategic retreat were highly negative to the environmental resources and were unaccepTable D.3-alternatives. Two alternatives were recommended by the TBS study that represented a hybrid of the original pre-Hurricane Andrew configuration and historic configuration alternatives. The final recommended alternative included strategic inlet closure, dune creation, backbarrier marsh creation, and the use of breakwaters, groins, and revetments.

3.3.5 U.S. Geological Survey

The U.S. Geological Survey (USGS) has a long history of conducting research on the biological resources, geology, and water resources of Louisiana. The National Mapping Division of the USGS has provided our country with standard 1:24,000 quadrangle maps depicting the nation's physical and cultural features since the 1800s, as well as a variety of other map products specifically for coastal Louisiana. Since 1986, the USGS has conducted three geoscience studies of erosion along Louisiana's Gulf shoreline and the Pontchartrain Basin:

1) The Louisiana Barrier Island Erosion Study,
2) The Western Louisiana Coastal Erosion Study, and
3) The Pontchartrain Basin Environmental Study.

Beginning in 1986, the USGS began the most in-depth and comprehensive investigation of the erosion and geologic framework of Louisiana's barrier islands to support coastal management and restoration planning. The USGS Louisiana Barrier Island Study produced two atlases entitled, "Atlas of Shoreline Changes in Louisiana from 1853 to 1989" (Williams et al. 1992) and "Atlas of Sea-Floor changes from 1878 to 1989 (List et al. 1994)".

The USGS shoreline change atlas provided a through review of the coastal erosion and wetland loss problems in Louisiana as a basis of this study (Penland et al. 1992). A pictorial and historical review of the importance of Louisiana's barrier islands to our state's environment, economy, and culture is provided by Davis (1992). Included in this illustrative masterpiece is information on Louisiana's settlement history, the first barrier island resort in the Isles Dernieres, Grand Isle, Grand Terre, pirates, hurricanes, fisheries and oil and gas (Davis 1992). Photo mosaics of the Isles Dernieres, Bayou Lafourche, Plaquemines, and Chandeleur barrier shorelines are included to provide information on the coastal geomorphology and human infrastructure in this area between 1986 and 1989 (Westphal and Penland 1992). A comprehensive analysis of detailed linear shoreline and area change rate patterns between 1887 and 1989 concludes this first atlas (McBride et al. 1992). Four time periods are investigated in this analysis of barrier island change: from 1855–1887 to 1922–1932, 1951–1956, 1973– 1978, and 1988–1989. This analysis documented that the rate of barrier shoreline change between 1855–1989 ranged between -18.0 ft/yr for the Plaquemines shoreline to -29.7 ft/yr for the Chandeleur Island shorelines to -32.2 ft/yr for the Bayou Lafourche shoreline, and -36.4 ft/yr for the Isles Dernieres shoreline. The average rate of barrier shoreline change for this time period is -29.1 ft/yr. Figure D.3- 6 is an example of the Timbalier Islands map product from the USGS Shoreline Change Atlas (Williams et al. 1992; McBride et al. 1992).

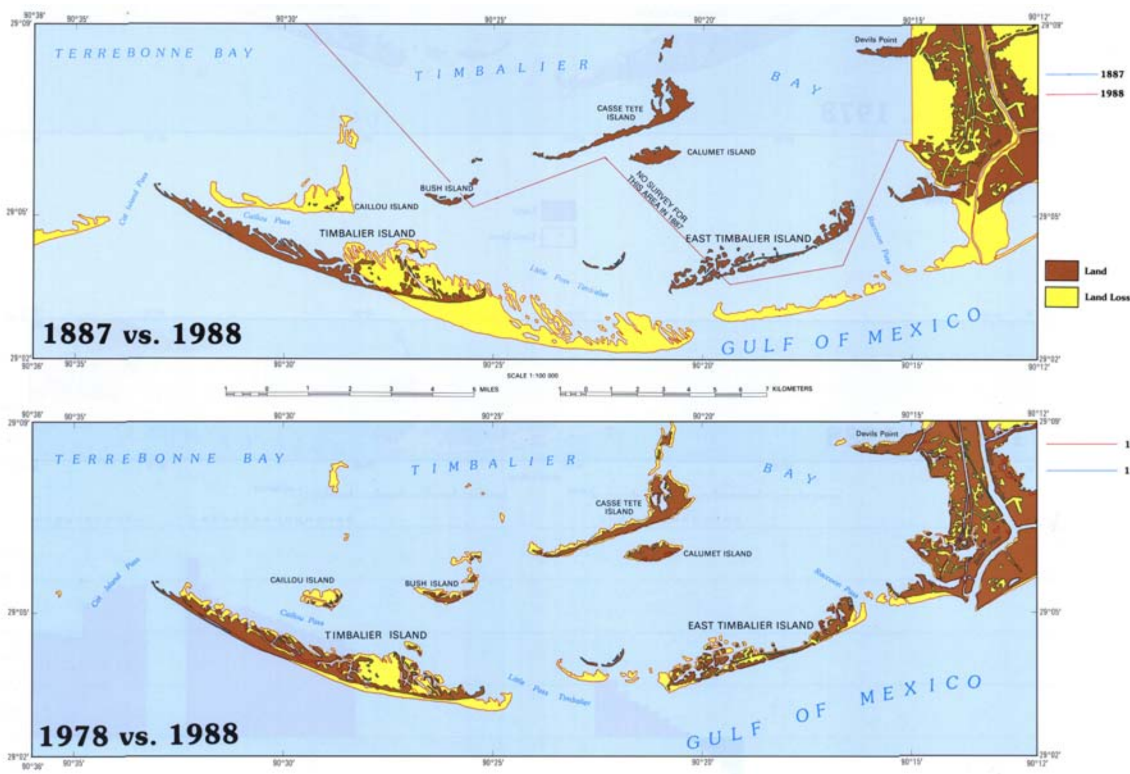


Figure D.3- 6. Shoreline change maps for the Timbalier Islands for 1887 to 1988 and 1978 to 1988 from the USGS Louisiana Barrier Island Erosion Study— "Atlas of Shoreline Changes for 1853 to 1989" (Williams et al. 1992; McBride et al. 1992).

The USGS seafloor change atlas provided the first regional bathymetric change of Louisiana's coast between Raccoon Point and Sandy Point including the Isles Dernieres, Bayou Lafourche, and Plaquemines barrier shorelines (List et al. 1994). This analysis was based on historic bathymetric hydrographic surveys by the U.S. Coast and Geodetic Survey between 1878–1891 and 1931–1936. The USGS conducted new bathymetric surveys between 1986 and 1989 to establish two time-periods of analysis for the 1880s to 1930s and 1930s to 1980s. Information on regional sea-floor changes, shoreline and nearshore sediment budgets, and large-scale coastal evolution are presented in the conclusions. Overall the results concluded that there is a large-scale pattern of littoral-induced coastal straightening due to deltaic headland erosion and embayment deposition in the Barataria Bight and the Cat Island Pass regions. The bulk of the bathymetric change and sediment transport has occurred at shoreface depths, deeper than assumed for breaking-wave processes. The processes responsible for this shoreface-depth of transport are poorly understood, but appear to be of primary importance in controlling the long-term evolution of the barrier shorelines west of the Mississippi River. The sediment budget analysis showed that the majority of the sand introduced into the littoral transport by muddy headland erosion is not lost from the system. These conclusions have significant implications for coastal restoration planning. Figure D.3- 7 is an example from the Timbalier Islands of the map product from the USGS Seafloor Change Atlas (List et al. 1994).

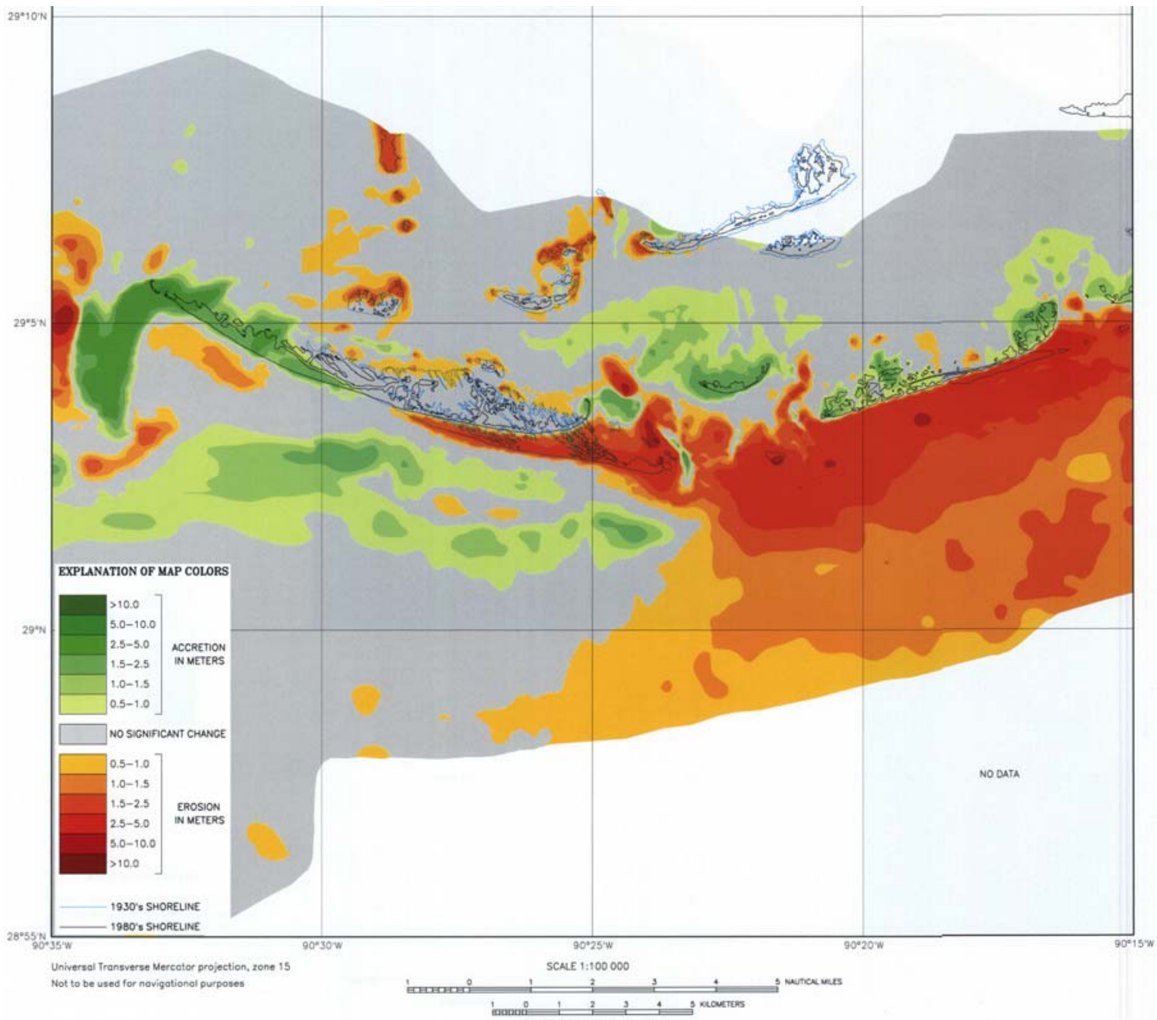


Figure D.3- 7. A seafloor change map for the Timbalier Islands from the 1930s to the 1980s from the USGS Louisiana Barrier Island Erosion Study—"Atlas of Seafloor Changes for 1978 to 1989" (List et al. 1994).

The USGS West Louisiana Coastal Erosion Study focused on the analysis of shoreline change, geologic framework, and sand resources for coastal erosion control in the Chenier Plain. Using historical U.S. Coast and Geodetic Topographic maps dated 1883 to 1957 and a 1994 Global Positioning System (GPS) survey, Byrnes et al. (1995) conducted an assessment of shoreline change between Sabine Pass and Southwest Pass. The average rate of shoreline change for the Chenier Plain was reported at -8.6 ft/yr with a range of -28.6 ft/yr to +22.3 ft/yr. Shoreline advance was documented on the updrift (east) sides of the Sabine, Calcasieu, and Mermentau jetties and along the zone of Atchafalaya River mudflat accretion in the vicinity of the Freshwater Bayou Canal. Framework geologic studies concentrated on the origin of the Lakes Calcasieu estuary and the development of the Chenier Plain (Nichols et al. 1992, 1994, and 1996). Penland et al. (1990) reported on the sediment resources for coastal erosion control along the Chenier Plain as well as the delta of the Mississippi River.

The USGS Pontchartrain Environmental Study concentrated on a variety of investigations from sediment quality framework geology, environmental modeling, circulation modeling, and shoreline change (Penland et al. 2001). The lowest rates of long-term shoreline change in the Pontchartrain Basin are found in Lake Maurepas at -3.2 ft/yr, and increase to -3.3 ft/yr for Lake Pontchartrain and -7.9 ft/yr for Lake Borgne. This west to east variation in erosion is a function of lake size and open water fetch, with Lake Maurepas the smallest lake and Lake Pontchartrain the largest.

3.3.6 Environmental Protection Agency

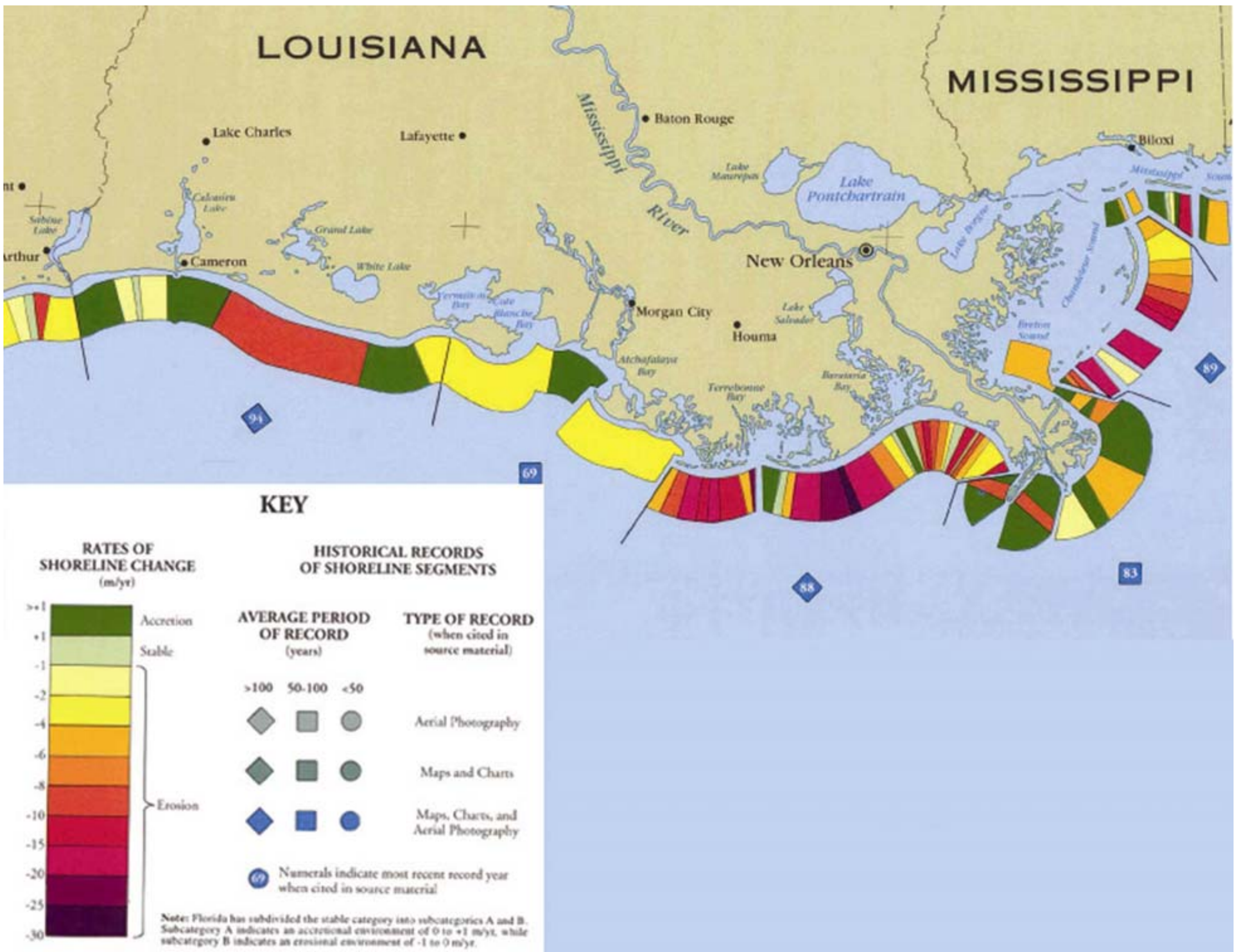
The Environmental Protection Agency (EPA) established the Gulf of Mexico Program (GMP) to provide stewardship of the coastal marine resources found in Texas, Louisiana, Mississippi, Alabama, and Florida. The Coastal Erosion Subcommittee was charged with coordinating the inventory of the status and trend of shoreline change in the Gulf Coast states. In the late 1980s the TX General Land Office, LA Department of Natural Resources, MS Department of Environmental Protection, ALA Department of Environmental Management, FL Department of Environmental Protection, regional universities, state geologic surveys, USGS, and USACE within the GMP Coastal Erosion Committee worked cooperatively to compile a map of historical shoreline changes in the Gulf of Mexico. The result was the publication of the map entitled “Historical Shoreline Change in the Northern Gulf of Mexico” by the EPA-GMP. Figure D.3- 8 presents the section of this map that depicts shoreline change for the entire coast of Louisiana. The average rate of shoreline change is -18.7 ft/yr, with a range of -98.4 ft/yr to shoreline advance (rate not mapped).

3.4 Shoreline Changes: 1855 TO 2002

3.4.1 Methodology

In this section, state-of-the-art computer maps and digital air photos are used to analyze changes in Louisiana’s shoreline. Three regions are examined: the Chenier Plain, Acadia Bays, and the Deltaic Plain.

The shoreline change results presented in this LCA chapter are based on existing historical cartographic and airborne imagery held in the digital archives of the Coastal Research Laboratory’s Geographic Information System (GIS) within the Pontchartrain Institute for Environmental Sciences at the University of New Orleans (UNO). The GIS covers the period between 1855 and 1989, as well as new air photo interpretation/GIS analysis between 1985 and 2002, and previously published papers and reports (Table D.3-2). This LCA chapter used state-of-the-art computer cartography and digital air photo interpretation to perform this shoreline change analysis (Anders and Byrnes 1871; Byrnes et al. 1991; McBride et al. 1991). All of the shoreline change results presented conform to U.S. National Map Accuracy Standards or better (American Society of Civil Engineers 1994). Previously published papers and reports that supplement this analysis include Morgan and Larimore 1957; Adams et al. 1978; Penland and Boyd 1981 and 1982; van Beek and Meyer-Arendt 1982; Morgan and Morgan 1983; Penland et al. 1990 b; McBride et al. 1992; Byrnes et al. 1995; McBride and Byrnes 1997.



The period of measurement spans more than 100 years for east and west Louisiana and is current to 1983/89 and 1994 respectively. The period of measurement for south-central Louisiana spans 50-100 years and is current to 1969.

Figure D.3- 8. Map depicting long-term shoreline changes in Louisiana by the Coastal Erosion Subcommittee of the Environmental Protection Agency’s Gulf of Mexico program (Penland 1996).

The long-term and short-term coastal change data are presented by geomorphic region and shoreline reaches. The area covered extends from the Texas to the Mississippi borders (Sabine Pass to the Pearl River), excluding the advancing land areas associated with the Mississippi and Atchafalaya Rivers. A total of 34 shoreline reaches were delineated. This data is presented in a format that subdivides coastal Louisiana into three geomorphic regions: A) Chenier Plain, B) Acadia Bays, and C) Deltaic Plain (Table D.3-3).

The long-term average shoreline change data (1855 – 1988) provide periodic information as to how existing coastal conditions developed. Long-term rates of change are available for the Chenier Plain, Deltaic Plain, and the Pontchartrain Basin exceeding 100 years. Long-term shoreline change data for the Acadia Bays are limited to slightly over 30 years. High quality short-term shoreline information at the two-decade scale is available for all areas and should provide the necessary information for restoration planning. Table D.3-4 lists the shoreline reaches with their lengths and the parishes in which they are found.

A shoreline reach is defined as a contiguous uniform section of shoreline based on the geomorphology, change trends, existence of man-made structures, and/or a combination of one or more of these coastal elements. Figure D.3- 9 is a map and Table D.3-depicting the 34 long-term shoreline change reaches for coastal Louisiana between 1855 and 1989. Figure D.3- 10 is a map and Table D.3-depicting the 34 short-term shoreline change reaches for coastal Louisiana between 1985 and 2002. Table D.3-5 lists the average long-term and short-term shoreline change rates and ranges. A variety of graphics also follow depicting barrier island area changes as a consequence of natural processes and human impacts.

The Chenier Plain region is located in west Louisiana and is the marginal deltaic plain of the Mississippi River as discussed previously in this chapter. Shoreline Reaches 1-10 make up the Chenier Plain. The Acadia Bays region is the oldest part of the Mississippi River Deltaic Plain and is geomorphically unique and distinct from the transgressive barrier shorelines to the east. The Acadia Bays represent the erosional remnants of the Teche/Maringouin delta complex. Trinity Shoal, Ship Shoal, and the Atchafalaya shell reefs are the transgressive depositional systems of this delta complex. Shoreline reaches 11-13 make up the Acadia Bays between Marsh Island and Point Au Fer Islands. They are situated in south-central Louisiana and include the Atchafalaya shell reefs. Southeast Louisiana is comprised of the four barrier shorelines discussed previously and the Pontchartrain Basin.

This section presents the most current analysis of historical rate and range of Louisiana Gulf shoreline change for the period 1855 to 2002. The historical area change for the barrier islands is presented for the period 1887 – 2002. This data set is designed to provide insight into the dynamic nature of Louisiana's Gulf shoreline. The framework geology and coastal program combined with hurricanes, periods of prolonged fair-weather, and man's activities all significantly influence the variability of the patterns, rates, and ranges of coastal change. Which linear shoreline or area rate of change should be used for restoration planning? First, the previous research history must be considered to understand our current knowledge of shoreline change in Louisiana. Next, the average short-term (1985–2002) change rate and range must be considered, because they provide the most current conditions for coastal management and restoration. In addition, the short-term change rate provides insight into how the coast responded to recent major storms (Andrew–1992, Isidore– 2002, Lily–2002) and CWPPRA restoration projects. hese change rates are presented below.

Table D.3-2. Shoreline Data Sources: 1855 to 2002

A. Chenier Plain[1]

Date	Source	Product
1932 - 1954	Morgan and Larimore	(1957) Published Paper
1954 - 1969	Morgan and Morgan	(1983) Published Report
1932 - 1969	Adams and others	(1978) Government Report
1883 - 1994	Byrnes and others	(1995) Published Paper
1985	U.S. Geological Survey	Government Photography
1998	U.S. Geological Survey	Government Photography

B. Acadia Bays[2]

Date	Source	Product
1932 - 1954	Morgan and Larimore(1957)	Published Paper
1954 - 1969	Morgan and Morgan (1983)	Published Report
1932 - 1969	Adams and others (1978)	Government Report
1985	U.S. Geological Survey	Government Photography
1998	U.S. Geological Survey	Government Photography

C. Mississippi River Delta Plain[3]

Date	Source	Product
1853 - 1855	National Ocean Survey	T-Charts
1877 - 1887	National Ocean Survey	T-Charts
1887 - 1989	McBride and others (1992)	Published Report
1922 - 1932	National Ocean Survey	T-Charts
1932 - 1954	Morgan and Larimore (1957)	Published Paper
1954 - 1969	Morgan and Larimore (1983)	Published Report
1932 - 1969	Adams and others (1978)	Government Report
1951 - 1956	U.S. Geological Survey	Quadrangle Maps
1978	U.S. Geological Survey	Quadrangle Maps
1978	NASA	Government Aerial Photography
1988	Gulf Coast Aerial Mapping Inc.	Commercial Aerial Photography
1992	Gulf Coast Aerial Mapping Inc.	Commercial Aerial Photography

1993	Gulf Coast Aerial Mapping Inc.	Commercial Aerial Photography
1996	Gulf Coast Aerial Mapping Inc.	Commercial Aerial Photography
1999	National Ocean Survey	Government Photography
2000	Gulf Coast Aerial Mapping Inc.	Commercial Aerial Photography
2000	Aerodata, Inc.	Commercial Aerial Photography
2002	Aerial Viewpoint, Inc.	Commercial Aerial Photography

[1] Sabine Pass east to Southwest Pass

[2] Marsh Island east to Point Au Fer

[3] Raccoon Island east to Sandy Point; Breton Island to North Chandeleur Island.

Table D.3-3. Louisiana Shoreline Change Geomorphic Regions

A. Chenier Plain Region

Region	Long-Term Date	Short-Term Date
1. Sabine Pass – Ocean View Beach	1883-1994	1985-1998
2. Ocean View Beach – Holly Beach	1883-1994	1985-1998
3. Holly Beach – Calcasieu Pass	1883-1994	1985-1998
4. Calcasieu Pass – Mermentau Outlet	1883-1994	1985-1998
5. Mermentau Outlet – Rockefeller Refuge	1883-1994	1985-1998
6. Rockefeller Refuge: West-East	1883-1994	1985-1998
7. Rockefeller: East-Mulberry Island	1883-1994	1985-1998
8. Mulberry Island – Freshwater Bayou	1883-1994	1985-1998
9. Freshwater Bayou – Chenier Au Tigre	1883-1994	1985-1998
10. Chenier Au Tigre – Southwest Pass	1883-1994	1985-1998

B. Acadia Bays Region

Region	Long-Term Date	Short-Term Date
11. Southwest Pass – Lake Point	1932-1969	1985-1998
12. Point Au Fer – Oyster Bayou	1932-1969	1985-1998
13. Oyster Bayou – Grand Caillou Bayou	1932-1969	1985-1998

.

C. Delta Plain Region

Region	Long-Term Date	Short-Term Date
C.I Isles Dernieres Barrier Shoreline		
14. Raccoon Island	1887-2002	1988-2002
15. Whiskey Island	1883-1994	1985-1998
16. Trinity Island	1883-1994	1985-1998
17. East Island	1883-1994	1985-1998
C. II. Bayou Lafourche Barrier Shoreline	1985-1998	
18. Timbalier Island	1883-1994	1985-1998
19. Timbalier Island (east section)	1883-1994	1985-1998
20. East Timbalier Island	1883-1994	1985-1998
21. Raccoon Spit	1884-2002	1988-2002
22. Caminada – Moreau Headland	1887-2002	1988-2002
23. Grand Isle	1887-2002	1988-2002
C. III Plaquemines Shoreline		
24. West Grand Terre Island	1884-2002	1988-2002
25. East Grand Terre	1884-2002	1988-2002
26. Chenier Ronquille	1884-2002	1988-2002
27. Shell Island	1884-2002	1988-2002
28. Scofield 1884-2002 1988-2002		
C. IV. Chandeleur Islands Shoreline		
29. Breton Island	1869-2002	1989-2002
30. Grand Gossier/Curlew Islands	1869-2002	1989-2002
31. North Chandeleur Islands	1855-2002	1989-2002
C. V. Pontchartrain Basin		
32. Lake Borgne	1850-1995	1960-1995
33. Lake Pontchartrain	1850-1995	1960-1995
34. Lake Maurepas	1899-1995	1960-1995

3.4.2 Shoreline Reaches

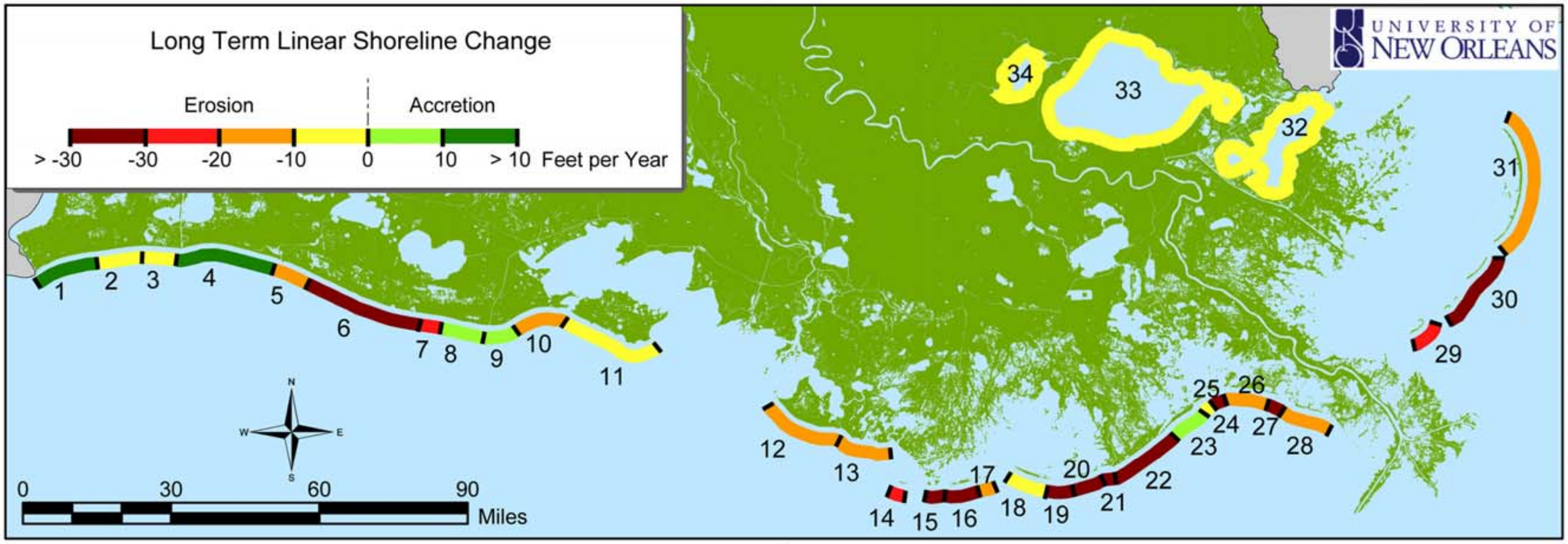
Chenier Plain

Reach 1. Sabine Pass-Ocean View Beach

Reach 1 stretches 128 miles east from Sabine Pass at the Texas/Louisiana border to Ocean View Beach in Cameron Parish (Figure D.3- 9). Littoral drift is towards the west. As a result, the eastern jetty of Sabine Pass traps westward moving sediment, thus promoting shoreline advancement. The morphology of this reach is characterized by a rip-rap armored shoreline at Ocean View Beach that transitions to a sandy washover-dominated barrier beach to the west. Johnson’s Bayou and Smith Bayou drain to the coast here. Eventually, wide muddy tidal flats backed by salt marsh begin to appear next to the Sabine Pass jetties, reflecting the interception of westward moving littoral drift and shoreline accretion (Penland and Suter 1989). Long Beach is Louisiana’s western most sandy beach. Between 1883 and 1994, the shoreline prograded seaward at a rate of +12.9 ft/yr with a range of +0.0/+28.0 ft/yr (Figure D.3- 9; Table D.3-5). Recently, the 1985–1995 rate of progradation has slowed to +1.2 ft/yr, and the behavior of this shoreline reach has become erratic, with changes rates varying -13.2/+14.7 ft/yr (Figure D.3- 10; Table D.3-5).

Reach 2. Ocean View Beach – Holly Beach

Shoreline Reach 2 is 10.1 miles long and lies in Cameron Parish. Western Louisiana’s major recreational beaches and seaside communities are found here between Ocean View Beach and Holly Beach along LA Highway 82. This line of coastal communities follows a series of chenier and beach ridges that provide the foundation for LA Highway 82. Since the construction of LA Highway 82 in the 1930s, this area has evolved into a series of recreation communities for Lake Charles and southwest Louisiana. The majority of the area’s commercial development is centered in Holly Beach, where several businesses and motels are found. This is the only road accessible area west of Calcasieu Pass to the beach. Shoreline morphology is highly variable, with a number of low cost, localized protection structures of rip-rap, sandy beaches backed by a variety of washover and low dune features, and narrow beaches eroding and scarping into higher upland ridges. An erosional shadow extends westward from Peveto Beach due to coastal structures to the east (Penland and Suter 1989). LA Highway 82 is frequently overtopped, and efforts to stabilize the shoreline with revetments have proven costly and less than successful. Because it is starved of longshore sediment supply from the east by the Calcasieu Pass Jetties, persistent erosion can be expected. The long-term shoreline change trend was erosional at -5.1 ft/yr between 1883 and 1994 with a range of +0.0/-9.9 ft/yr (Figure D.3- 9; Table D.3-5). The short-term shoreline change trend for 1985–1998 has slowed and remained erosional at -4.3 ft/yr, with a variable range of -11.6/+3.6 ft/yr (Figure D.3- 10, Table D.3-5). Historically, the zone of highest erosion between Holly Beach and Peveto Beach has progressively shifted westward to the vicinity of Constance Beach over the last several decades. Hurricane Carla in 1961, a Saffir-Simpson category 4 storm, was the last major hurricane to impact the Holly Beach vicinity. Such a storm today could destroy part of Highway 82 and cause catastrophic property damage in these coastal communities.



	Reach Name	Long Term Rate (ft/yr)	Time Period		Reach Name	Long Term Rate (ft/yr)	Time Period
1[1]	Sabine Pass to Ocean View Beach	+12.9	1883 to 1994	18	Timbalier Island (Western Section)	-4.1	1887 to 2002
2[1]	Ocean View Beach to Holly Beach	-5.1	1883 to 1994	19	Timbalier Island (Eastern Section)	-42.9	1887 to 2002
3[1]	Holly Beach to Calcasieu Pass	-4.2	1883 to 1994	20	East Timbalier Island	-61.2	1887 to 2002
4[1]	Calcasieu Pass to Mermentau Outlet	+11	1883 to 1994	21	Raccoon Spit	-81.8	1884 to 2002
5[1]	Mermentau Outlet to Rockefeller Refuge: West	-18.7	1883 to 1994	22	Caminada-Moreau Headland	-41.4	1884 to 2002
6[1]	Rockefeller Refuge: West to East	-34.8	1883 to 1994	23	Grand Isle	+2.0	1884 to 2002
7[1]	Rockefeller Refuge: East to Mulberry Island	-25.0	1883 to 1994	24	West Grand Terrre Island	-7.7	1884 to 2002
8[1]	Mulberry Island to Freshwater Bayou	+9.2	1883 to 1994	25	East Grand Terre Island	-38.0	1884 to 2002
9[1]	Freshwater Bayou to Chenier Au Tigre	+7.4	1883 to 1994	26	Chenier Ronquille	-19.7	1884 to 2002
10[1]	Chenier Au Tigre to Southwest Pass	-10.1	1883 to 1994	27	Shell Island	-38.5	1884 to 2002
11[2]	Southwest Pass to Lake Point	-5.0	1932 to 1969	28	Scofield	-11.6	1884 to 2002
12[2]	Point Au Fer to Oyster Bayou	-11.6	1932 to 1969	29	Breton Island	-20.9	1869 to 2002
13[2]	Oyster Bayou to Grand Caillou Bayou	-10.6	1932 to 1969	30	Grand Gossier and Curlew Islands	-62.8	1869 to 2002
14	Raccoon Island	-27.4	1887 to 2002	31	North Chandeleur Islands	-18.6	1855 to 2002
15	Whiskey Island	-56.0	1887 to 2002	32	Lake Borgne	-7.9	1850 to 1995
16	Trinity Island	-38.4	1887 to 2002	33	Lake Pontchartrain	-3.3	1899 to 1995
17	East Island	-17.0	1887 to 2002	34	Lake Maurepas	-3.2	1899 to 1995

[1] Byrnes et al., 1995 [2] Morgan and Morgan, 1977

Figure D.3- 9. A diagram of the 34 coast-wide shoreline reaches in Louisiana with the average long-term shoreline change rate between 1855 and 1989

Reach 3. Holly Beach – Calcasieu Pass

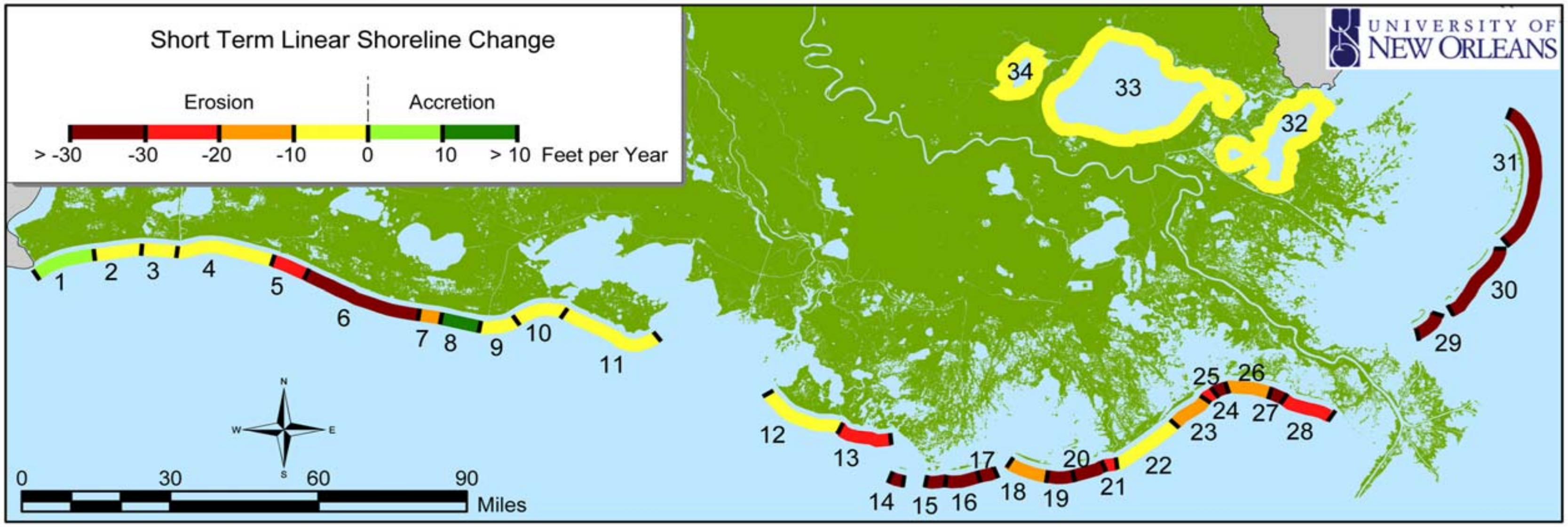
Between Holly Beach and the western jetty of Calcasieu Pass in Cameron Parish lies the 6.1 mile long Shoreline Reach 3. LA Highway 82 parallels the shoreline; little coastal development has taken place over the years. This is a low profile sandy shoreline backed by washover and dune terrace features (Penland and Suter 1989). Mud Pass intersects the shoreline southeast of Mud Lake. The long-term shoreline change rates here averaged -4.2 ft/yr between 1883 and 1994 with a range of -9.9/+ 0.0 ft/yr. Recently, the short-term rate of change between 1985 and 1998 has slowed to -0.1 ft/yr with a range of -13.13/+14.7 ft/yr (Figure D.3- 10; Table D.3-5). This area lies directly in the lee of the Calcasieu Pass jetties and is sheltered from the predominately southeasterly wave approach. Longshore sediment transport is to the west. Immediately west of the Calcasieu Pass jetties is a short zone of progradational mudflats that transition within a mile to the west into an erosional sandy shoreline.

Reach 4. Calcasieu Pass –Mermentau Channel

Shoreline Reach 4 stretches between the east jetty of Calcasieu Pass to the Mermentau-Gulf Navigation Channel (MGNC), which diverts the natural Mermentau River flow directly south to the coast. The area lies on the updrift side of the Calcasieu Pass jetties, which is intercepting westward moving longshore sediment transport. Hackberry Beach is downdrift of the old Mermentau River mouth, and Rutherford Beach lies immediately to the west. These beach communities are connected to LA Highway 82 by a series of short roads, which are the only access points to the shoreline east of Calcasieu Pass. Low dunes and washover terraces transition west to mudflats that widen and front salt marsh adjacent to Calcasieu Pass (Penland and Suter 1989). The average long-term shoreline change rate between 1883 and 1994 was +11.0 ft/yr with a range of +6.6/+16.4 ft/yr (Figure D.3- 9; Table D.3-5). Sometime between 1985 and 1998, the shoreline change trend switched from accretion to erosion and the new average short-term change rate was measured at -9.6 ft/yr, with a variation between -44.6 ft/yr and +39.5 ft/yr (Figure D.3- 10; Table D.3-5).

Reach 5. Mermentau Channel – Rockefeller Refuge (West)

Shoreline Reach 5 measures 7.4 miles and extends from the entrance of the Mermentau-Gulf Navigation Channel (MGNC) to the western boundary of the Rockefeller Wildlife Management Area and Game Refuge (Rockefeller Refuge) in Cameron Parish. The MGNC jetties define the western section of Shoreline Reach 5; otherwise there are no significant coastal developments in this area other than widely scattered oil and gas structures. Dominant longshore sediment transport is to the west. Prominent features in the vicinity of the western side of this reach are Club Canal, Hog Bayou, and Beach Prong Bayou. East of the MGNC, the increasing erosional conditions and a diminishing coarse-grain (sand and shell) sediment availability lead to beaches often perched landward onto the backbarrier marsh. Perched beaches are characterized by an erosional platform of truncated marsh extending into the surf zone. The average long-term rate of shoreline change is -18.7 ft/yr, with a range of + 0.0/-29.5 ft/yr between 1883 and 1994 (Figure D.3- 9; Table D.3-5). Short-term shoreline change rates indicate that erosion accelerated between 1985 and 1998 to -24.4 ft/yr, with a range of +0.5 ft/-36.8 ft/yr (Figure D.3- 10; Table D.3-5).



	Reach Name	Short Term Rate (ft/yr)	Time Period		Reach Name	Short Term Rate (ft/yr)	Time Period
1	Sabine Pass to Ocean View Beach	+1.2	1985 to 1998	18	Timbalier Island (Western Section)	-13.4	1988 to 2002
2	Ocean View Beach to Holly Beach	-4.3	1985 to 1998	19	Timbalier Island (Eastern Section)	-179.4	1988 to 2002
3	Holly Beach to Calcasieu Pass	-0.1	1985 to 1998	20	East Timbalier Island	-36.3	1988 to 2002
4	Calcasieu Pass to Mermentau Outlet	-9.6	1985 to 1998	21	Raccoon Spit	-20.5	1988 to 2002
5	Mermentau Outlet to Rockefeller Refuge: West	-24.4	1985 to 1998	22	Caminada-Moreau Headland	-8.6	1988 to 2002
6	Rockefeller Refuge: West to East	-39.2	1985 to 1998	23	Grand Isle	-14.9	1988 to 2002
7	Rockefeller Refuge: East to Mulberry Island	-16.9	1985 to 1998	24	West Grand Terrre Island	-21.7	1988 to 2002
8	Mulberry Island to Freshwater Bayou	+51.8	1985 to 1998	25	East Grand Terre Island	-50.1	1988 to 2002
9	Freshwater Bayou to Chenier Au Tigre	-5.6	1985 to 1988	26	Chenier Ronquille	-17.2	1988 to 2002
10	Chenier Au Tigre to Southwest Pass	-8.5	1985 to 1998	27	Shell Island	-101.5	1988 to 2002
11	Southwest Pass to Lake Point	-6.4	1985 to 1998	28	Scofield	-20.9	1988 to 2002
12	Point Au Fer to Oyster Bayou	-9.7	1985 to 1998	29	Breton Island	-48.1	1989 to 2002
13	Oyster Bayou to Grand Caillou Bayou	-28.3	1985 to 1998	30	Grand Gossier and Curlew Islands	-126.5	1989 to 2002
14	Raccoon Island	-60.5	1988 to 2002	31	North Chandeleur Islands	-45.7	1989 to 2002
15	Whiskey Island	-86.0	1988 to 2002	32	Lake Borgne	-7.1	1960 to 1995
16	Trinity Island	-62.5	1988 to 2002	33	Lake Pontchartrain	-3.8	1960 to 1995
17	East Island	-38.6	1988 to 2002	34	Lake Maurepas	-2.5	1960 to 1995

Figure D.3- 10. A diagram of the 34 coast-wide shoreline reaches in Louisiana with the average short-term shoreline change rate between 1985 and 2002.

Reach 6. Rockefeller Refuge: West to East

Shoreline Reach 6 is 24.7 miles long and comprises the Rockefeller Refuge proper in Cameron and Vermillion parishes, which is the erosional hotspot of the Chenier Plain in west Louisiana. This shoreline reach begins in the vicinity of Beach Prong Bayou and extends just east of Rollover Bayou. No significant structures are found along this shoreline except an occasional camp or oil and gas structure. Longshore sediment transport is to the west. The 1883 to 1994, long-term, shoreline erosion rates are much higher than for Shoreline Reach 5 at -34.8 ft/yr (Figure D.3- 9; Table D.3-5). The long-term shoreline erosion range rate is -41.0ft/-26.3 ft/yr. There is a recent increase in erosion, with the 1985–1995 average short-term change rate measured at -39.2 ft/yr, with the change range rate variable at -53.4/+15.1 ft/yr (Figure D.3- 10; Table D.3-5). Because of the persistently high rates of erosion and the limited supply of coarse-trained (sand and shell) material in the littoral zone, the morphology of the Rockefeller Refuge shoreline is washover dominated by beaches perched on an erosional marsh platform outcropping in the intertidal and surf zone (Penland and Suter 1989). Where coastal lakes occur near the shoreline, erosion has truncated them to form straight sandy and/or shelly barrier beaches. In some cases, particularly where the lakes are large, a tidal inlet breaches the barrier shoreline. These inlets can be permanent or ephemeral depending on sediment supply and storm activity.

Reach 7. Rockefeller Refuge: East to Mulberry Island

Shoreline Reach 7, between the east side of Rockefeller Refuge and Mulberry Island continues to be erosional, but the rates are less than those found to the west at the Rockefeller Refuge. Here, the long-term average rate of erosion between 1883 and 1994 was -25 ft/yr, and the change range is -32.8/-16.4 ft/yr (Figure D.3- 9; Table D.3-5). The 1985 to 1998 short-term erosion rate shows a decrease to -16.9 ft/yr with a range of -22.7/-11.2 ft/yr (Figure D.3- 10; Table D.3-5). The diminishing erosion rates in this shoreline reach reflect the encroachment of the Atchafalaya River mud stream from the east (Wells and Kemp 1981; Roberts 1998). The high rates of erosion in this shoreline reach are decreasing with increasing episodic mudflat accretion from the Atchafalaya River to the east, since the 1950/60s (Roberts and Huh 1995). The shoreline morphology of the reach reflects this trend of decreasing erosion rates. In the west, perched beaches are common, with eroded marsh platforms outcropping in the surf zone backed by a variety of washover features (Penland and Suter 1989). Eastward, the beaches become more continuous, and low relief dunes are interdispersed within washover terraces and flats as the coarse-grained sediment supply (sand and shell) increases near Mulberry Island. Periodic mudflats are also forming in the Mulberry Island area, helping to diminish the erosion there.

Reach 8. Mulberry Island to Freshwater Bayou

Shoreline Reach 8 is 8.2 miles long and lies entirely in Vermillion Parish. The Mulberry Island to Freshwater Bayou shoreline reach is the zone of historic Atchafalaya River mudflat accretion and shoreline progradation (Morgan and Larimore 1957). Nowhere else in the Chenier Plain of west Louisiana is the gain of new land as pronounced (Roberts and Huh 1995). Long-term shoreline progradation between 1883 and 1994 was measured at +9.2 ft/yr with a range of -3.3/+16.4 ft/yr (Figure D.3- 9; Table D.3-5). For the period of 1985 and 1998, the rate of shoreline advance accelerated to +51.8 ft/yr (Figure D.3- 10; Table D.3-5). The short-term shoreline change rate range for this same time period is -14.8 /+104.7 ft/yr. The process of mudflat progradation is primarily a storm related process. Cold fronts, tropical storms, and hurricanes appear to move viscous fluid mud onshore during storm passage (Roberts 1998). The fluid mud welds to the coast, prograding the shoreline as much as hundreds of feet per event. Salt marsh vegetation is recruited onto these nutrient-rich mudflats, contributing to shoreline progradation. The hurricanes of 1985 pushed up large quantities of fluid mud that contributed significantly to the progradation of this reach (Penland et al. 1989). One of the most phenomenal events of mud deposition occurred east of where Mulberry Island is truncated by the Gulf shoreline. Hurricane Audrey in 1957, a category 4 storm, impacted west Louisiana and deposited a huge “Mud Arc” onto the coast 11,350 feet long and 1,000 feet wide (Morgan et al. 1958). This shoreline advanced hundreds of feet as a result of the Hurricane Audrey impact. Fluid mud from the Atchafalaya River appears to accumulate on the inner continental shelf offshore from Mulberry Island to Chenier Au Tigre and is pushed by strong onshore wind and wave driven storm currents. Fresh fluid mudflats and older sun-dried, desiccated mudflats are common throughout Shoreline Reach 8. Mudflat progradation is enhanced by the USACE beneficial use of dredge material to the west of Freshwater Bayou Canal from navigation maintenance dredging. Muddy washover fans are continuous landward of these mudflats, and some of the lushest, most mosquito-infested salt marsh in Louisiana is found here (Penland and Suter 1989).

Reach 9. Freshwater Bayou – Chenier Au Tigre

Shoreline Reach 9 lies within Vermillion Parish and is 7.9 miles in length. Between Freshwater Bayou Canal and Chenier Au Tigre, this coast shoreline transitions from mudflat progradation in the west to sandy shoreline erosion in the east (Penland and Suter, 1989). Bill Ridge is a prominent set of chenier ridges that parallels the backshore of Tigre Point. Today, this area is almost devoid of development except for an occasional camp or oil and gas structure. Prior to 1940, Chenier Au Tigre was a permanent settlement. Frequent hurricane impacts eventually lead to the abandonment of this community and today the few camps that remain are only seasonally occupied. Several small bayous are truncated by shoreline retreat and are periodically open or closed depending on storm activity. West to east the shoreline orientation changes dramatically from a south facing shore to a southeast facing shore. As a consequence, the longshore sediment transport direction tends to bifurcate to the east and west at Tigre Point. Chenier Au Tigre acts as a headland, providing a source of sand and shell material for the development of a narrow beach backed by washover terraces and flats. An erosional scarp extends westward from Chenier Au Tigre. Between 1883 and 1994 the average long-term shoreline change rate was +7.4 ft/yr and the range is +4.9/+9.9 ft/yr (Figure D.3- 9; Table D.3-5). The recent short-term change rate has reversed to erosion at -5.6 ft/yr and the rate of -11.3 /+0.1 ft/yr (Figure D.3- 10; Table D.3-5).

Table D.3-4 Louisiana Shoreline Reaches, Lengths, and Parishes

Reach No.	Reach Name	Length (miles)	Parish
1	Sabine Pass to Ocean View Beach	12.8	Cameron
2	Ocean View Beach to Holly Beach	10.1	Cameron
3	Holly Beach to Calcasieu Pass	6.1	Cameron
4	Calcasieu Pass to Mermentau Channel	20.3	Cameron
5	Mermentau Channel to Rockefeller Refuge West	7.4	Cameron
6	Rockefeller Refuge West to Rockefeller Refuge East	24.4	Cameron, Vermillion
7	Rockefeller Refuge East to Mulberry Island	4.3	Vermillion
8	Mulberry Island to Freshwater Bayou	8.2	Vermillion
9	Freshwater Bayou to Chenier Au Tigre	7.9	Vermillion
10	Chenier Au Tigre to Southwest Pass	10.1	Vermillion
11	Southwest Pass to Lake Point	21.1	Iberia
12	Point Au Fer to Oyster Bayou	16.8	Terrebonne
13	Oyster Bayou to Grand Caillou Bayou	11.4	Terrebonne
14	Raccoon Island	3.2	Terrebonne
15	Whiskey Island	4.3	Terrebonne
16	Trinity Island	7.0	Terrebonne
17	East Island	3.4	Terrebonne
18	Timbalier Island: Western Section	8.2	Terrebonne
19	Timbalier Island: Eastern Section	6.0	Terrebonne, Lafourche
20	East Timbalier Island	6.3	Lafourche
21	Raccoon Spit	2.8	Lafourche
22	Caminada-Moreau Headland	8.0	Lafourche, Jefferson
23	Grand Isle	7.9	Jefferson
24	West Grand Terrre Island	2.2	Jefferson
25	East Grand Terre Island	2.8	Plaquemines
26	Chenier Ronquille	8.7	Plaquemines
27	Shell Island	3.2	Plaquemines
28	Scofield	10.2	Plaquemines
29	Breton Island	6.6	Plaquemines
30	Grand Gossier and Curlew Islands	17.1	Plaquemines, St. Bernard
31	North Chandeleur Islands	30.7	St. Bernard
32	Lake Borgne	74.1	St. Bernard, Orleans, St. Tammany
33	Lake Pontchartrain	102.9	Orleans, Jefferson, St. Charles, St. John the Baptist, Tangipahoa, St. Tammany
34	Lake Maurepas	28.3	St. John the Baptist, Livingston, Tangipahoa

Table D.3-5 The Long-term (1855-1989) and Short- Term (1985-2002) Coast-wide Shoreline Changes

1. Sabine Pass-Ocean View Beach			2. Ocean View Beach-Holly Beach		
Dates	Average Rate of Change (ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1883-19941	+12.9	0.0/+28.0	1883-19941	-5.1	0.0/-9.9
1985-1998	+1.2	13.13/+14.7	1985-1998	-4.3	-11.6/+3.6
3. Holly Beach-Calcasieu Pass			4. Calcasieu Pass-Mermentau Outlet		
Dates	Average Rate of Change (ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1883-19941	-4.2	0.0/-9.9	1883-19941	+11.0	+16.4/+6.6
1985-1998	-0.1	10.5/+7.3	1985-1998	-9.6	-44.6/+39.5
5. Mermentau Channel-Rockefeller Refuge: West			6. Rockefeller Refuge: West-East		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1883-19941	-18.7	0.0/-2 9.5	1883-19941	-34.8	-26.3/-41.0
1985-1998	-24.4	-36.8/+0.5	1985-1998	-39.2	-53.4/+15.1
7. Rockefeller Refuge: East-Mulberry Island			8. Mulberry Island-Freshwater Bayou		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1883-19941	-25.0	-32.8/-16.4	1883-19941	+9.2	-3.3/+16.4
1985-1998	-16.9	-22.7/-11.2	1985-1998	+51.8	-14.8/+104.7
9. Freshwater Bayou-Chenier Au Tigre			10. Chenier Au Tigre-Southwest Pass		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1883-19941	+7.4	+4.9/+9.9	1883-19941	-10.1	-4.9/-13.1
1985-1998	-5.6	-11.3/+0.1	1985-1998	-8.5	-19.5/+1.1
11. Southwest Pass-Lake Point			12. Point Au Fer-Oyster Bayou		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1932-19692	-10.0	-19.0/+5.0	1932-19692	-11.6	-24.0/+11
1985-1998	-6.4	-18.7/+4.6	1985-1998	-9.7	-18.7/-3.1
13. Oyster Bayou-Grand Caillou Bayou			14. Raccoon Island		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1932-19692	-10.6	-11.0/-8	1887-1934	-26.2	58.8/+30.2
1985-1998	-28.3	-115.0/-6.5	1934-1956	-17.9	-37. 8/+3.28
	1956-1978	-20.0	-47.3/-9. 8		
	1978-1988	-58.2	-111.6/-26.9		
	1887-2002	-27.4	-28.9/-24.9		
	1988-2002	-60.5	-144.5/-8.6		

Table D.3-5 (cont.)

15. Whiskey Island			16. Trinity Island		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1887-1934	-54.0	-90.6/-38.4	1887-1934	-40.5	-45.6/-33.8
1934-1956	-49.0	-76.1/-9.2	1934-1956	-15.6	-76.5/-1.7
1956-1978	-43.5	-60.7/-12.8	1956-1978	-28.5	-48.3/+16.4
1978-1988	-98.8	-211.0/-38.1	1978-1988	-58.3	-83.0/-32.5
1887-2002	-56.0	-77.5/-45.7	1887-2002	-38.4	-47.9/-34.3
1988-2002	-86.0	-139.4/-48.8	1988-2002	-62.5	-107.3/-41.1
17. East Island			18. Timbalier Island (west section)		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1887-1934	-26.6	-57.8/+41.4	1887-1934	+22.4	-8.2/+59.4
1934-1956	-13.4	-46.3/+3.28	1934-1956	+8.0	-43.0/+113.2
1956-1978	-4.5	-17.8/+28.2	1956-1978	-1.7	-24.6/+11.5
1978-1988	-28.6	-68.9/+19.7	1978-1988	-13.2	-74.5/+90.6
1887-2002	-17.0	-34.6/+5.1	1887-2002	-4.1	-31.0/+20.9
1988-2002	-38.6	-64.0/-14.0	1988-2002	-13.4	-118.7/+31.9
19. Timbalier Island (East section)			20. East Timbalier Island		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1887-1934	-31.5	-60.4/-14.1	1887-1934	-145.7	-149.3/-137.8
1934-1956	-30.3	-47.9/-4.6	1934-1956	-17.9	-45.6/+8.6
1956-1978	-65.8	-151.2/-7.9	1956-1978	-38.4	-171.3/-13.5
1978-1988	-147.4	-277.2/-42.4	1978-1988	-26.5	-251.0/+15.1
1887-2002	-42.9	-48.6/-37.3	1887-2002	-61.2	-74.3/-49.2
1988-2002	-179.4	-205.5/-153.3	1988-2002	-36.3	-65.5/-4.9
21. Raccoon Spit			22. Caminada-Moreau Headland		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1887-1934	-135.5	-140.4/-131.6	1887-1934	-51.9	-148.6/-18.4
1934-1956	-57.4	-88.6/-19.7	1934-1956	-37.8	-108.3/+56.8
1956-1978	-56.4	-107.3/-16.1	1956-1978	-31.0	-70.2/+5.9
1978-1988	-93.6	-277.5/-26.3	1978-1988	-44.7	-137.8/-9.2
1887-2002	-81.8	-88.9/-72.9	1884-2002	-41.4	-59.5/-6.3
1988-2002	-20.5	-52.3/-2.8	1988-2002	-8.6	-27.1/+10.9

Table D.3-5 (cont.)

23. Grand Isle			24. West Grand Terre Island		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1887-1934	-3.1	-47.6/+22.7	1884-1932	-11.3	-24.3/+9.2
1934-1956	0	-13.8/+25.3	1932-1956	+16.7	+7.6/+24.0
1956-1978	+8.4	-29.2/+70.9	1956-1973	-6.6	-41.4/+15.8
1978-1988	+17.0	-8.2/+54.8	1973-1988	-23.5	-45.3/+16.4
1887-2002	+2.0	-8.1/+14.6	1884-2002	-7.7	-16.1/-2.2
1988-2002	-14.9	-73.2/+3.7	1988-2002	-21.7	-44.3/+20.3
25. East Grand Terre			26. Chenier Ronquille		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1884-1932	-21.8	-32.5/-2.0	1884-1932	-34.3	-63.7/+8.2
1932-1956	-27.8	-40.1/-18.4	1932-1956	-13.1	-68.3/+70.9
1956-1973	-50.0	-88.6/-19.7	1956-1973	-18.1	-108.3/+0.7
1973-1988	-31.6	+19.4/-51.2	1973-1988	-25.9	-88.9/+48.9
1884-2002	-38.0	-69.8/-24.9	1884-2002	-19.7	-52.7/+9.0
1988-2002	-50.1	-62.3/+258.8-	1988 -2002	-17.2	-109.1/+8.3
27. Shell Island			28. Scofield		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1884-1932	-12.6	-46.6/+8.2	1884-1932	-11.5	-52.2/+25.3
1932-1956	-19.6	-43.3/+31.9	1932-1956	-18.0	-45.3/+48.9
1956-1973	-8.0	-27.6/+43.3	1956-1973	+9.0	-4.6/+37.1
1973-1988	-79.5	-159.8/-11.8	1973-1988	-109.7	-49.6/+12.5
1884-2002	-38.5	-61.8/-7.0	1884-2002	-11.6	-32.4/+0.6
1988-2002	-101.5	-233.0/+112.2	1988-2002	-20.9	-93.5/+37.2
29. Breton Island			30. Grand Gossier/Curlew Islands		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1869-1922	-23.6	-42.7/-2.0	1869-1922	-55.0	-75.2/-30.5
1922-1951	-13.4	-40.7/+34.5	1922-1951	-28.6	-51.9/-5.3
1951-1978	-20.6	-53.8/+20.0	1951-1978	-61.7	-148.0/+2.7
1978-1989	-13.4	-77.8/+12.5	1978-1989	-78.4	-135.5/+22.7
1869-2002	-20.9	-31.1/-4.0	1869-2002	-62.8	-71.2/-53.2
1989-2002	-48.1	-72.4/-26.5	1989-2002	-126.5	-199.4/-20.4

Table D.3-5 (cont.)

31. North Chandeleur Islands			32. Lake Borgne		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1855-1922	-17.5	-48.9/+19.4	1850-1995	-7.9	-27.6/-2.6
1922-1951	-18.4	-52.5/+9.84	1960-1995	-7.1	-29.8/0.0
1951-1978	-32.8	-172.2/-2.3			
1978-1989	-40.0	-90.2/-12.2			
1869-2002	-18.6	-57.6/+11.2			
1989-2002	-45.7	-226.4/-16.3			
31. North Chandeleur Islands			32. Lake Borgne		
Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)	Dates	Average Rate of Change(ft/yr)	Change Rate Range (ft/yr)
1850-1995	-3.3	-13.4/+19.7	1899-1995	-3.2	-9.2/0.0
1960-1995	-3.8	-22.3/+4.6	1960-1995	-2.5	-10.8/+5.2

[1] *Byrnes et al., 1995*

[2] *Morgan and Morgan, 1977*

Reach 10. Chenier Au Tigre to Southwest Pass

Located in Vermillion Parish, Shoreline Reach 10 is 10.2 miles long. The Paul J. Rainey Wildlife Sanctuary and State Wildlife Refuge occupy the majority of this shoreline reach. Sediments eroded from Chenier Au Tigre and transported to the east have formed a nearly continuous sand and shell beach backed by washover terraces and flats (Penland and Suter 1989). Low dunes are scattered along this coast during periods of fair-weather. Wave energy is lower here than elsewhere on the Chenier Plain due to the presence of Trinity Shoal offshore and the occurrence of the Atchafalaya mud stream offshore. Long-term erosion rates from 1883 to 1994 averaged -10.1 ft/yr, with a range of -13.1/-4.9 ft/yr (Figure D.3- 9; Table D.3-5). Between 1985 and 1998, the short-term rate of erosion was -8.5 ft/yr, ranging -19.5/+1.1 ft/yr (Figure D.3-10; Table D.3-5). Along this shoreline reach, the offshore gradient of the continental shelf decreases and becomes shallower. Just west of the Southwest Pass, shell reefs become common in the nearshore and provide a wave dampening effect in the adjacent shoreline. The largest reef in this area is the Tete Butte Reef.

Acadia Bays

Reach 11. Southwest Pass to Lake Point

Approximately 21.5 miles long, Shoreline Reach 11 lies completely in Iberia Parish at Marsh Island. Marsh Island is the home of the Russell Sage Foundation-Marsh Island State Wildlife Refuge as well as the Shell Keys National Wildlife Refuge. Undeveloped, except for a few oil and gas structures, the Marsh Island shoreline is managed for wildlife and fishery resources. Marsh management features can be seen along this coast including levees, weirs, and other types of water control structures. The presence of numerous large shell reefs has a significant influence on shoreline morphology. Shell reefs limit the water energy reaching the shore and form localized headlands that are a source of shell for localized barrier shoreline development. The largest headlands associated with shell reefs are found at Grosse Isle Point and Mound Point. The beaches are discontinuous and are often perched on marsh with an erosional muddy platform extending onto the surf zone. Pocket beaches are common, backed by shelly washover features. Numerous tree-covered headlands are found where shell reefs are contiguous to the shoreline. Large tidal channels, such as Bayou Blanc and Oyster Bayou, dissect the coast and enter the Gulf along the south shore of Marsh Island. Long-term and short-term shoreline change trends between 1932–1969 and 1985–1998, averaged -50 ft/yr and -6.4 ft/yr respectively (Figure D.3-s 9 and 10; Table D.3-5). The long- and short-term erosion ranges are -19.0/+5.0 ft/yr and -18.7/+4.6 ft/yr for 1932-1969 and 1985–1998, respectively.

Reach 12. Point Au Fer – Oyster Bayou

In Terrebonne Parish, Shoreline Reach 12 is 16.8 miles long and encompasses Point Au Fer Island. The beaches along Point Au Fer Island are continuous and composed primarily of shell. Shelly washover flats are the dominant coastal landforms. Because of the shelly coarse-grained character of the sediments, the beaches are very steep in slope. No development is found along the Point Au Fer Island shoreline except for oil and gas activities. Numerous tidal channels, such as Locust Bayou and Mosquito Bayou, crisscross Point Au Fer Island and enter the Gulf along the south shore. The long-term shoreline change rate between 1932 and 1969 was -11.6 ft/yr, with a range of -24.0/ +11.0 ft/yr (Figure D.3- 9; Table D.3-5). The short-term shoreline change rates indicate there is continuing erosion at a lower rate of -9.7 ft/yr for 1985 and 1998, with a range of -18.7/ -3.1 ft/yr (Figure D.3- 10; Table D.3-5). Erosion has breached Point Au Fer from the mainland of Point Au Fer Island in recent years. In this same area, the increasing influence of the Atchafalaya mud stream is seen in the form of muddy washover fans and the periodic appearance of progradation mudflats after storms (Roberts 1998).

Reach 13. Oyster Bayou to Grand Caillou Bayou

Shoreline Reach 13 lies in Terrebonne Parish and is 11.5 miles in length. This shoreline reach stretches along the Caillou Bay shoreline between the large tidal inlets of Oyster Bayou and Grand Caillou Bayou. Oyster Bayou drains Four League Bay, and Grand Caillou Bayou drains the numerous lakes and bayous north of Caillou Bay, including Lake Merchant and Caillou Lake. The Caillou Bay shoreline is not a continuous shoreline, but a series of discontinuous marsh islands with south-facing perched shell and sand beaches. There is not strong evidence of significant longshore sediment transport along this coast. The long-term shoreline change rate was -10.6 ft/yr between 1932 and 1969, with a range of -11.0/-8.0 ft/yr (Figure D.3- 9; Table D.3-5). Between 1985 and 1998, the short-term rate of shoreline erosion accelerated to -28.3 ft/yr with a range of -11.5/-6.5 ft/yr (Figure D.3- 10; Table D.3-5). The erosion rates along this reach increase east to west as the wave sheltering effects of the Isles Dernieres decrease in the same direction.

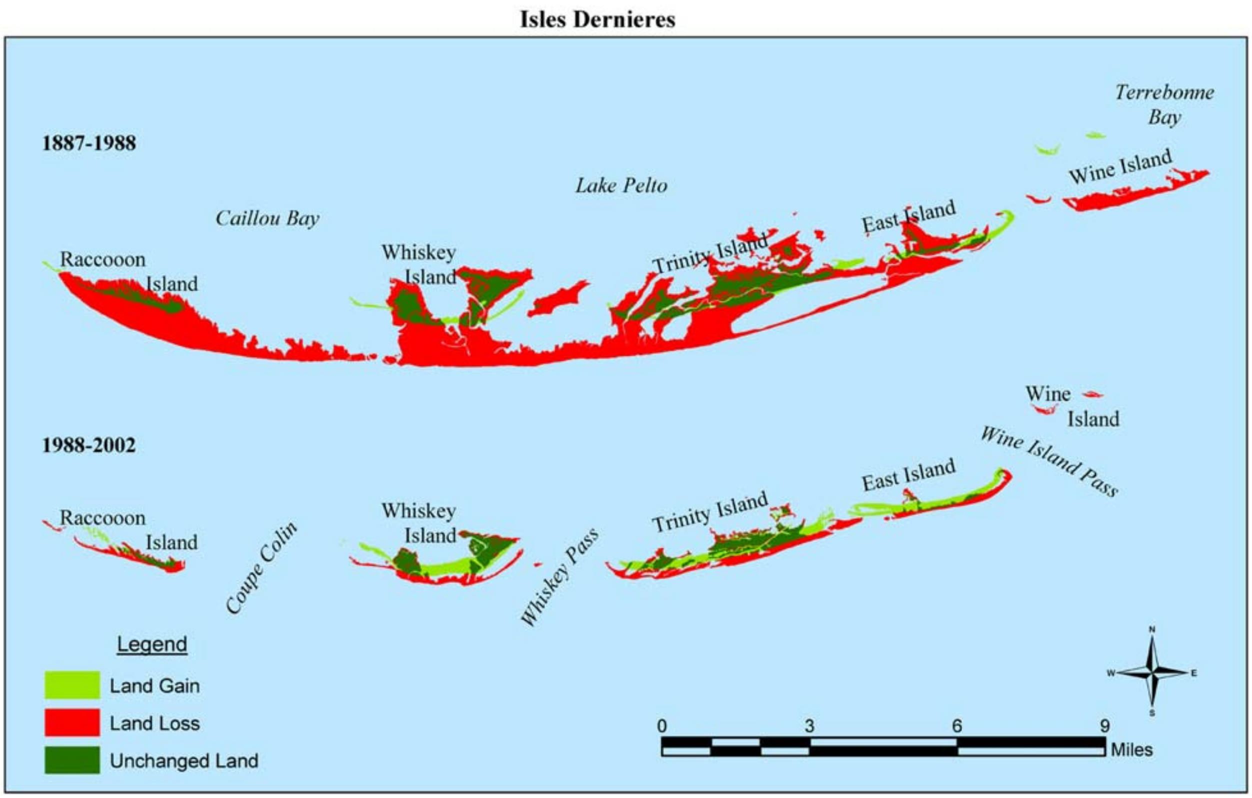
Delta Plain

Isles Dernieres Barrier Shoreline

The Isles Dernieres barrier shoreline represents a barrier island arc 22.0 miles long in Terrebonne Parish (Penland et al. 1985; 1988). Four Shoreline Reaches: (14) Raccoon Island;

(15) Whiskey Island; (16) Trinity Island; and (17) East Island make up the Isles Dernieres (Figure D.3- 11). For more than 150 years, the Isles Dernieres, also known as "Last Island" served Louisiana and the nation as an important commercial and recreational resource (Davis 1992). Mineral extraction and fisheries harvesting are interwoven inshore and offshore of the Isles Dernieres. The first major coastal resort in Louisiana was located here and was washed away by the great hurricane of 1856 (Davis 1990; Bultman 2002). The Isles Dernieres are also the location of the first four Coastal Wetland Planning, Protection, and Restoration Act (CWPPRA) projects of 1990 (Penland et al. 2003 a,b). These projects included: Raccoon Island (TE-29), Whiskey Island (TE-27), Trinity Island (TE-24) and East Island (TE-20).

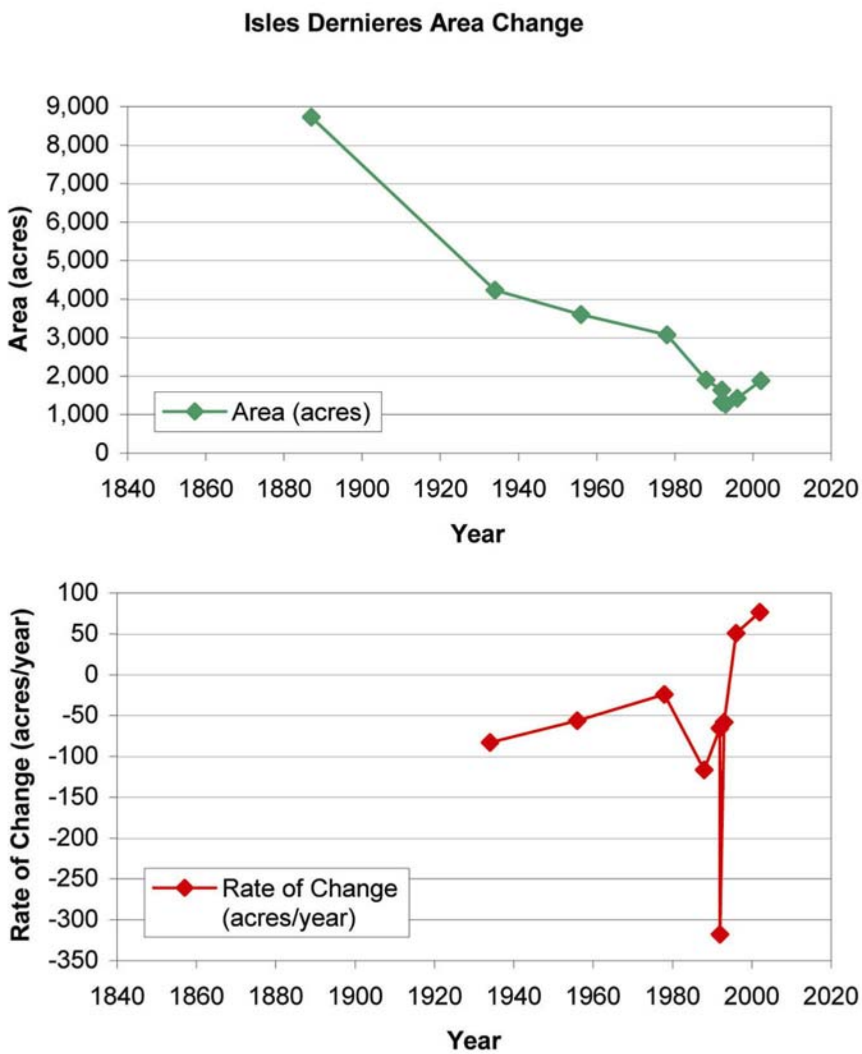
The long-term (1987–2002) rate of shoreline change for the Isles Dernieres was -34.7 ft/yr with a range of -56.0/-17.0 ft/yr (Table D.3-6). The short-term (1988–2002) rate of shoreline change was -61.9 ft/yr with a range of -60.5/-38.6 ft/yr. It is interesting to note the long-term and short-term shoreline changes reported by McBride et al. (1992) current for 1887–1888 are similar at -39.1 ft/yr and -63.0 ft/yr, respectively.



The Isles Dernieres contains Shoreline Reaches: 14) Racoon Island, 15) Whiskey Island, 16) Trinity Island, and 17) East Island

Figure D.3- 11. Historical modern map overlays for the Isles Dernieres for 1887 –1988 and 1988–2002.

The long-term area change of the Isles Dernieres was 8,724 acres in 1887 to 1,879 in 2002 (Table D.3-7). After hurricane Andrew in 1992 the Isles Dernieres decreased to 1,267 acres by 1993 (Figure D.3- 12). The long-term rate of area change between 1887 and 2002 was -62.3 ac/yr or a total decrease of -82.2% (Figure D.3- 12). The 1988–2002 area rate decrease was -25.0 ac/yr or a -18.4% decrease. The long-term (1887–2002) and short-term (1988–2002) disappearing dates were 2034 and 2075 respectively. McBride and other 1992 predicted the long-term and short-term disappearance dates at 2015 and 2004 for 1887–1998 and 1978–1988 respectively. The new 2002 LCA historical area data for the Isles Dernieres extends the long-term and short-term disappearance dates by 60 years and 30 years respectively.



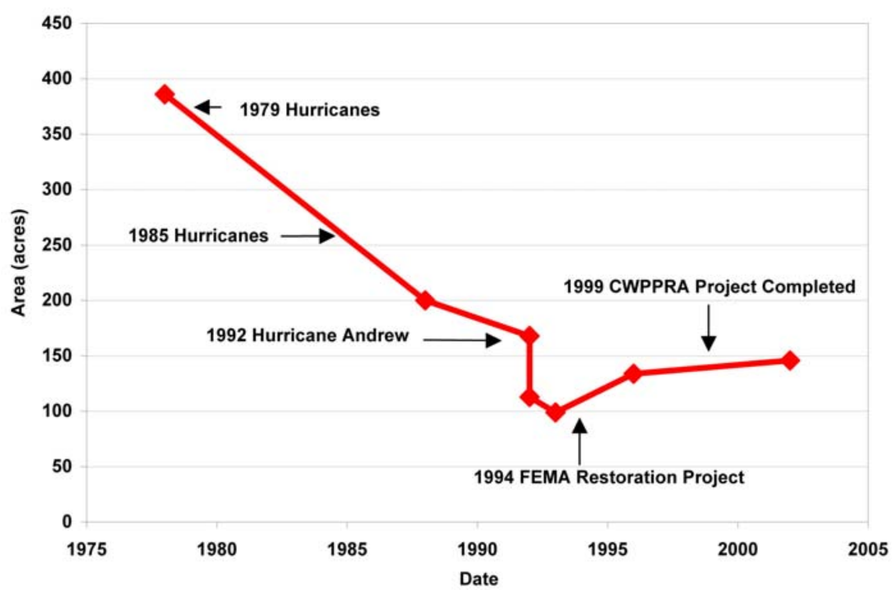
Note the area decreases between 1978 – 1988 and 1992 – 1993 related to hurricane activity. The area and positive rate increase is a function of the construction of 2 FEMA and 4 CWPPRA projects after 1994 (Penland et al. 2003).

Figure D.3- 12. Graph of the area changes and area rate of change for the Isles Dernieres between 1887 and 2002.

Reach 14. Raccoon Island

Raccoon Island, Shoreline Reach 14, is 3.2 miles long and located in Terrebonne Parish. Raccoon Island is the largest shorebird rookery in the Isles Dernieres. A sandy beach with well-vegetated washover terraces backed by thick groves of black mangrove and salt marsh are found here (Ritchie et al., 1989). The recurved spit at the west end is low and dominated by washover flats. The long-term shoreline change rate between 1887 and 2002 was -27.4 ft/yr with a range of -28.9/-24.9 ft/yr (Figure D.3- 9; Table D.3-5). The short-term shoreline rate was -60.5 with a range of -144.5/-8.6 ft/yr between 1988 and 2002 (Figure D.3- 10; Table D.3-5). The shoreline change rate increased between 1887 – 2002 and 1988 – 2002 from -27.4 ft/yr to -60.5 ft/yr. The long-term trend since 1887 for Raccoon Island has been a decrease in the area of the original Isles Dernieres (Figure D.3-s 11 and 12).

Since 1978, Raccoon Island has rapidly decreased in area (Table D.3-9). From 1978 to 1988, Raccoon Island reduced in size from 368.2 to 200.2 acres (Figure D.3- 13). During this time-period, multiple hurricane impacts occurred in 1979 (Bob and Claudette) and in 1985 (Danny, Elena, and Juan). From 1988 to 1992, Raccoon Island further decreased in area from 200.2 acres to 167.8 acres. With the impact of 1992’s Hurricane Andrew, the area of Raccoon Island continued to decrease even further to 112.8 acres. By 1993, Raccoon Island had further reduced in area to 99.2 acres. The FEMA restoration project of 1994 increased the size of Raccoon Island increased to 127.2 acres by 1996. The CWPPRA TE-29 segmented breakwater project further increased the area of Raccoon Island to 145.5 acres by 2002 (Penland et al. 2003 b).



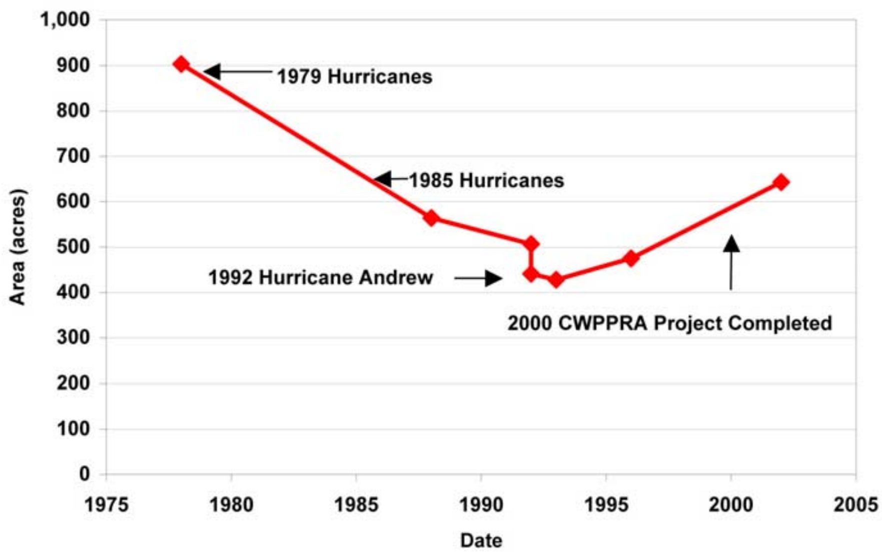
Significant shoreline events are illustrated along the area time-series line.

Figure D.3- 13. A time-series documenting the historical area changes in Raccoon Island (TE-25) between 1978 and 2002.

Reach 15. Whiskey Island

Whiskey Island is Shoreline Reach 15, which is 4.3 miles long in Terrebonne Parish. The long-term shoreline change rate between 1887 and 2002 was -56.0 ft/yr with a range of -77.5/-45.7 ft/yr (Figure D.3- 9; Table D.3-5). The short-term shoreline change rate was -86.0 ft between 1988 and 2002 with a range of -139.4/-48.4 ft/yr (Figure D.3- 10; Table D.3-5).

Prior to restoration, the morphology of Whiskey Island was dominated by washover flats and isolated washover terraces (Ritchie et al. 1989). The CWPRRA restoration project (TE-27) at Whiskey Island created an artificial dune 4-6 ft. in elevation, which was 2-3 feet above the natural pre-restoration surface (Penland et al. 2003 b). As seen throughout the Isles Dernieres, Whiskey Island is historically erosional and decreasing in area. Between 1978 and 1988, Whiskey Island decreased in area from 904.4 acres to 564.2 acres (Figure D.3- 14, Table D.3-10). This was a time when multiple hurricanes impacted the area in 1979 (Bob and Claudette) and 1985 (Danny, Elena, and Juan). By 1992, Whiskey Island had decreased to 505.6 acres. During the 1992 hurricane season, Hurricane Andrew impacted this area dramatically, reducing Whiskey Island to 440.8 acres. By 1993 it had further decreased in area to 428.4 acres. Post storm recovery processes increased the area of Whiskey Island to 474.8 acres by 1996. Construction of the Whiskey Island project (TE-27) began in February 1998 and was completed in August 1998. By 2002, the area of Whiskey Island had increased to 642.8 acres, a 36% increase in area (Figure D.3- 14). Further larger scale restoration is critically needed to maintain the island against the ongoing erosive forces of coastal storms.

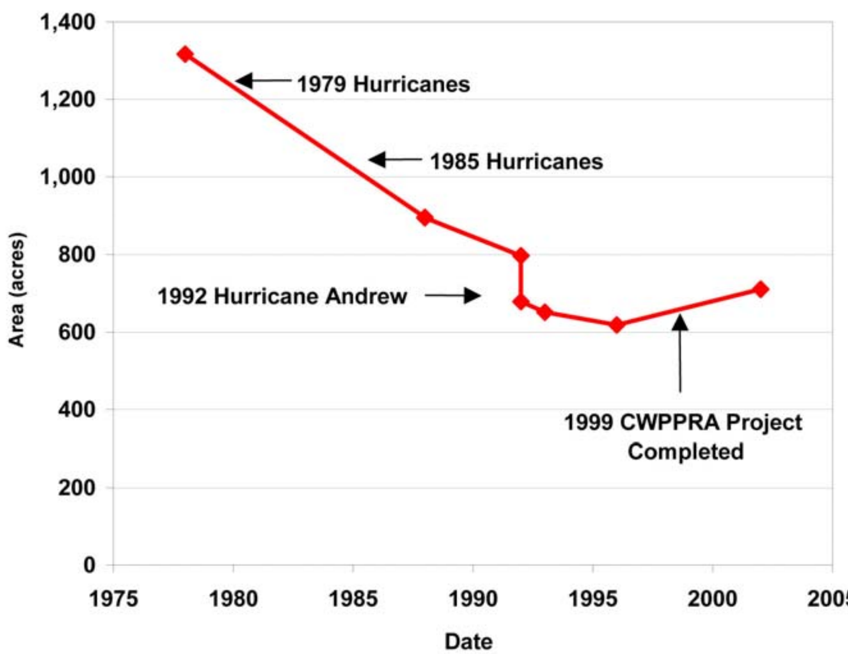


Significant shoreline events are illustrated along the area time-series line.

Figure D.3- 14. A time-series documenting the historical area changes in Whiskey Island (TE-27) between 1978 and 2002.

Reach 16. Trinity Island

Trinity Island, Shoreline Reach 16, is 17.0 miles long and lies in Terrebonne Parish. The largest of the Isles Dernieres islands, morphologically it is a remnant of the original mainland marsh and well-vegetated by black mangroves and salt marshes (Ritchie et al. 1989). Trinity Island is historically eroding (Figure D.3- 11; Table D.3-11). Between 1978 and 1988, Trinity Island decreased in area from 1,317.1 acres to 894.6 acres (Figure D.3- 12). This was a time period of multiple hurricanes in 1979 (Bob and Claudette) and 1985 (Danny, Elena, and Juan). By 1992, Trinity Island further decreased to 796.5 acres (Table D.3-11). During the 1992 hurricane season, Hurricane Andrew impacted this area, reducing Trinity Island to 678.5 acres and by 1993, the island decreased further to 651.4 acres. By 1996, the area of Trinity Island continued to decrease to 617.4 acres. After restoration, Trinity Island increased in area from 617.4 to 710.1 acres by 2002 (Penland et al. 2003 b). The long-term shoreline change rate between 1887 and 2002 was -38.4 f/yr with a range of -47.9/-34.3 ft/yr (Figure D.3- 9; Table D.3-5). The 1988–2002 short-term change rate was -62.5 ft/yr with a range of -107.3/-41.1 ft/yr (Figure D.3- 10, Table D.3-5). The acceleration between the long-term and short-term shoreline change rates is linked to the major hurricane impacts of 1992/2002. Further large scale restoration is critically needed to maintain the island against the ongoing erosive forces of coastal storms.



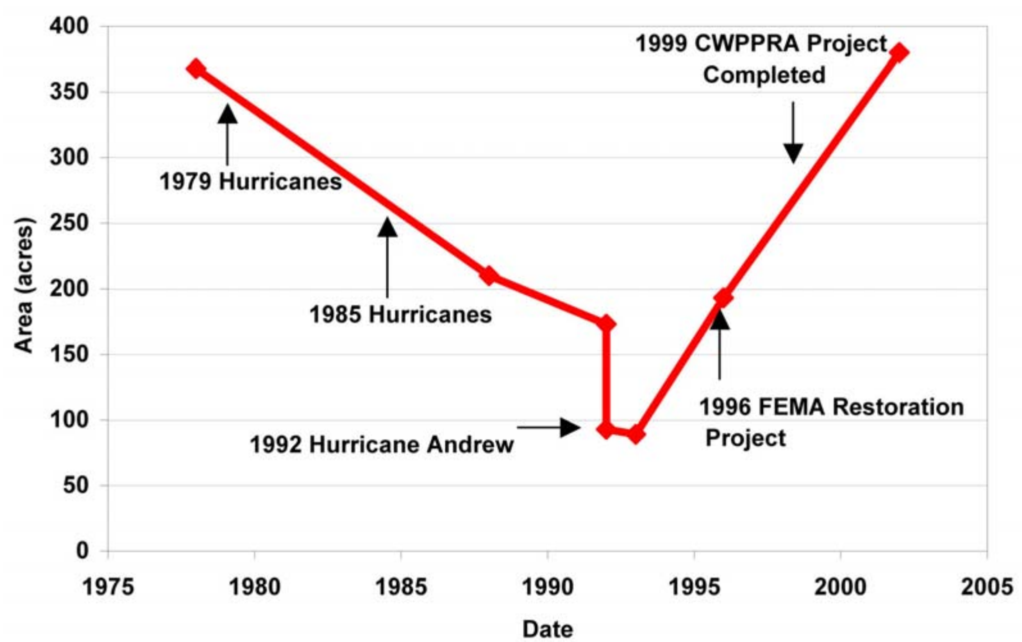
Significant shoreline events are illustrated along the area time-series line.

Figure D.3- 15. A time-series documenting the historical area changes in Trinity Island (TE-24) between 1978 and 2002.

Reach 17 East Island

East Island Shoreline Reach 17 is 3.4 miles long and lies in Terrebonne Parish. East Island has been rapidly eroding since 1887 (Figure D.3- 11). Prior to restoration, East Island was rapidly eroding and decreasing in area (Table D.3-12). In 1978, East Island was 368.2 acres in area, and by 1988 it had decreased in size to 202.2 acres (Figure D.3- 16).

The long-term shoreline change between 1887 and 2002 was -17.0 ft/yr with a range of -34.6/-5.1 ft/yr (Figure D.3- 9; Table D.3-5). Short-term, between 1988 and 2002, the shoreline erosion rates accelerated to -38.6 ft/yr with a range of -64.0/-14.0 ft/yr (Figure D.3- 10; Table D.3-5). During this period of time multiple hurricane impacts occurred in 1979 (Bob and Claudette) and in 1985 (Danny, Elena and Juan). By 1992, East Island had continued to lose land and measured 173.4 acres in size. After Hurricane Andrew made landfall in 1992, East Island was further reduced to 93.4 acres, and this continued into 1993 when East Island reached 88.5 acres in size. Following Hurricane Andrew, FEMA did an emergency restoration project east of the former Terrebonne Parish restoration site, resulting in East Island enlarging from 88.5 acres in 1993 to 193.1 acres in 1996 (Penland et al. 2003 a). The CWPPRA East Island restoration was completed in 1998, and the area of the island increased from 193.1 acres to 380.4 acres by 2002. Ongoing restoration will be needed to sustain this island.



Significant shoreline events are illustrated along the area time-series line.

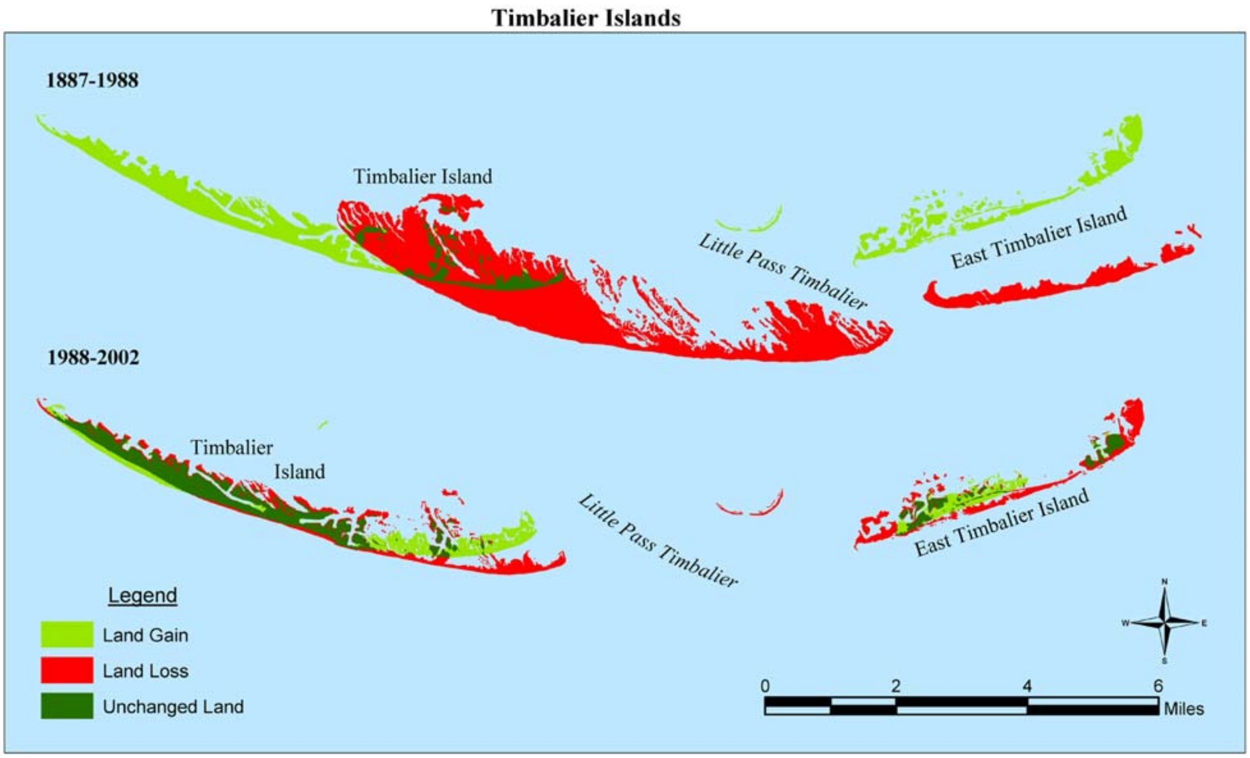
Figure D.3- 16. A time-series of the area of East Island from 1978 to 2002.

Bayou Lafourche Barrier Shoreline

The Bayou Lafourche barrier shoreline stretches 46.0 miles from the west end of Timbalier Island in Terrebonne Parish past East Timbalier Island and Fourchon in Lafourche Parish to Elmer’s Island and Grand Isle in Jefferson Parish (Ritchie et al. 1995). The barrier islands and mainland of Bayou Lafourche shoreline support the commercial, recreational, and residential heartland of Louisiana’s Gulf coast. The Timbalier Islands support onshore and offshore oil and gas development and production. To the east, Belle Pass is the entrance to Bayou Lafourche and Port Fourchon, the largest and fastest growing oil and gas port in the Gulf of Mexico and America. Along the Caminada-Moreau coast of the Bayou Lafourche headland, the Louisiana Offshore Oil Port, Inc. (LOOP) pipeline, the Shell Mars Pipeline, and pipelines from BP, Amoco, Chevron, Texaco and others move millions of barrels of oil and billions of cubic feet of gas into America daily.

Fourchon Beach and Elmer's Island have been Louisiana recreational areas for generations. Cheniere Caminada is the site of a historic community destroyed by the hurricane of 1893. Grand Isle is the only developed barrier island in Louisiana and supports the oil and gas industry, a residential community, tourism, the International Grand Isle Tarpon Rodeo, and more. Erosion and hurricanes threaten this coast. The Bayou Lafourche barrier shoreline consists of Shoreline Reaches: (18) Timbalier Island: West Section, (19) Timbalier Island: East Section, (20) East Timbalier Island, (21) Raccoon Spit, (22) Caminada-Moreau Headland, and (23) Grand Island.

The long-term shoreline changes along this coast average -24.6 ft/yr with a range of -81.8/+2.0 ft/yr for 1887–2002 (Table D.3-6). For 1998 to 2002, the short-term rate of shoreline change was -45.6 ft/yr with a range of -179/-9.6 ft/yr. The average short-term and long-term shoreline change rates for the Bayou Lafourche barrier shoreline are a simplification of change for a very complex and rapidly changing coastal area. The average rate of shoreline change for the Bayou Lafourche barrier shoreline allows its comparison with the average rates of change for the Isles Dernieres, Plaquemines, and Chandeleur Islands barrier shorelines (Table D.3-6). All four of these barrier shoreline systems are geologically distinct.



The Timbalier Islands consist of Timbalier Island and East Timbalier Island separated by Little Pass Timbalier. Over the last 115 years, Timbalier Island has literally migrated into the position of Shoreline Reach 18 from Shoreline Reach 19 (Figure D.3-s 9 and 10).

Figure D.3- 17. Historical map overlays for the Timbalier Islands for 1887 - 1988 and 1988 - 2002.

The Timbalier Islands are comprised of Shoreline Reaches 18, 19, and 20. Historically, the area of the Timbalier Islands have undergone large negative and positive area rate changes. Between 1887 and 1934 the area of the Timbalier Islands decreased from 4,142 ac to 2,875 ac at a rate of -27.0 ac/yr (Table D.3-13). Between the next two periods, 1934–1955 and 1956–1978, the Timbalier Islands increased from 2,875 ac to 3,280 ac to 3,693 ac at a rate of + 18.8 ac/yr respectively (Figure D.3- 17). This was a period of extensive backbarrier canal dredging and dredge spoil placement to support oil and gas development that inadvertently increased the area of the Timbalier Island areas. The large decrease in the area between 1978 and 1988 is a function of the extension of the Belle Pass jetties to the east and the disruption of the dominant longshore sediment transport to the west. The combination of a diminishing sediment supply and hurricanes between 1988 and 1996 continued to drive island barrier loss between 1996 and 2002.

Reach 18. Timbalier Island: Western Section

Shoreline Reach 18 consists of the modern day shoreline of Timbalier Island in Terrebonne Parish. This island is 8.2 miles long. Over the last 115 years, Timbalier Island has migrated 2.5 miles to the west by the erosion of its east end and the recurved spit extension of its west end (Figure D.3- 17). This long-term rate of shoreline change was -4.1 ft/yr between 1887 and 2002 with a range of -31.01/ +20.9 ft/yr (Figure D.3- 9, Table D.3-5). Between 1988 and 2002, the short-term erosion rate accelerated to -13.4 ft/yr with a range of -118.7 ft/yr to +31.9 ft/yr. The high rates of change reflect the impact of the 1992/2002 hurricanes. Since the 1960s, the sediment supply to Timbalier Island has been disturbed by the Belle Pass jetties’ updrift. Sediment that would naturally move westward around Belle Pass is now trapped on the updrift side of these jetties, and an erosional shadow extends into the area of the Timbalier Islands. Between 1978 and 2002, hurricanes were frequent, occurring in 1985, 1992, and 2002.

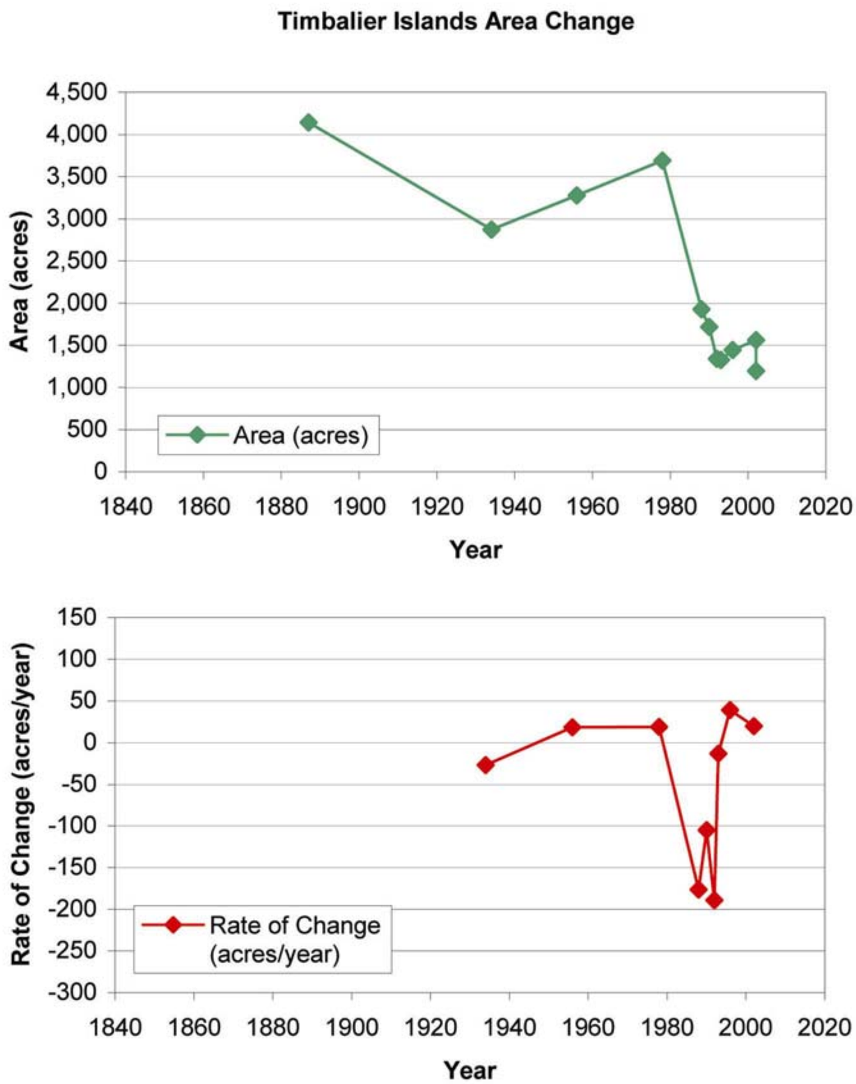
Reach 19. Timbalier Island: East Section

Shoreline Reach 19 is the Timbalier Island: East Section that is 6.0 miles long and lies in Terrebonne and Lafourche Parishes. This reach was the location of the east end of Timbalier Island in the 1880s before it migrated to the west. Historical maps of shoreline change have provided insight into the erosion process during the rapid westward migration by Timbalier Island through the erosion of its east end and sediment movement to the west (Figure D.3- 18). The long-term erosion rate here was -42.9 ft/yr with a range of -48.6/-37.3 ft/yr between 1887 – 2002 (Figure D.3- 9; and Table D.3-5). Recent short-term erosion rates between 1988 and 2002 were measured at -179.4 ft/yr (Figure D.3- 10; and Table D.3-5). The short-term erosion range is -205.5/153.3 ft/yr. The combination of the 1985/1992/2002 hurricanes and disruption of the westward sediment transport by the Belle Pass jetties have all contributed to the very high erosion rates here.

Reach 20. East Timbalier Island

Shoreline Reach 20 lies in Lafourche Parish and consists of East Timbalier Island, which is 6.3 miles (Figure D.3- 17). East Timbalier Island is occupied by a major oil and gas operation at the inshore Timbalier Bay field. The island supports major offshore production operated by Pioneer Natural Resources, Inc. East Timbalier Island is known for the massive rip-rap seawall along its Gulf shoreline and numerous revetments landward of it. The combination of the position of East Timbalier Island immediately downdrift of the Bayou Lafourche headland and the Belle Pass jetties create one of the most erosional areas in coastal Louisiana (Ritchie et al. 1995).

The long-term erosion rate between 1887 and 2002 was 61.2 ft/yr with a range of -74.3/-49.2 ft/yr (Figure D.3- 9; Table D.3-14). The short-term erosion rate between 1988 and 2002 decreased to -36.3 ft/yr with a range of -65.5/-4.9 ft/yr (Figure D.3- 10; Table D.3-14). The erosion rate diminished here in spite of the 1992/2002 hurricanes. This shoreline erosion decrease is partially related to the construction of CWPPRA restoration project TE-25/30 in 2000, which created +109 acres of new land (Penland et al. 2003 b).



Note area decreases between 1887-1934 and 1978 – 1993 are related to hurricane impacts. The area increase between 1934 and 1978 and 1993 – 2002 are related to oil and gas development with dredge spoil deposits and CWPPRA restoration respectively.

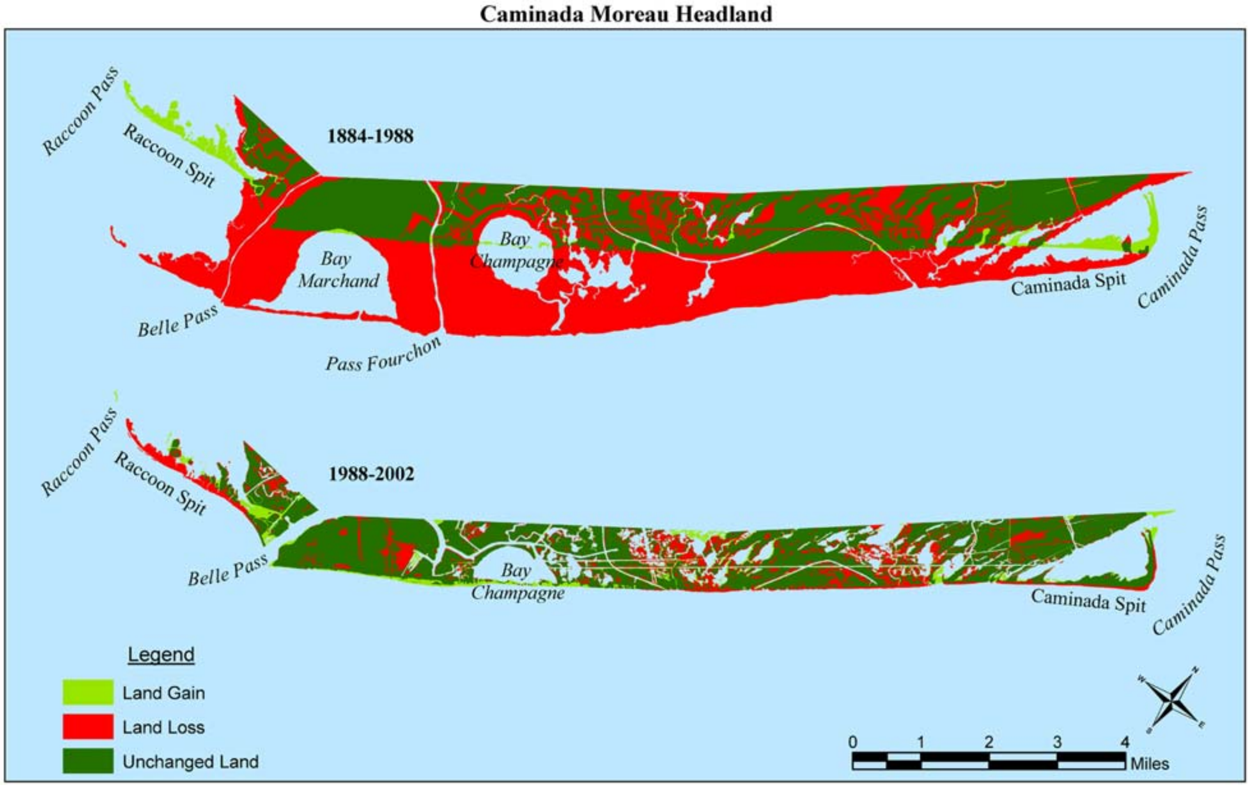
Figure D.3- 18. Graph of the area change and area rate of change for the Timbalier Islands between 1887 and 2002.

Reach 21. Raccoon Spit

Raccoon Spit is located immediately west of and contiguous to the west side of Belle Pass at the Caminada-Moreau coast. Raccoon Spit is 2.8 miles long and lies in Lafourche Parish (Figure D.3- 18). This spit recurves west into Raccoon Pass. Recurved spit positions, washover terraces, and low hummocky dunes are found on the surface of this coastal landform (Ritchie et al. 1995). One of the largest erosional shadows is found from the west jetty of Belle Pass past Raccoon Spit to the Timbalier Islands. Raccoon Spit experienced the highest rates of long-term erosion from 1887 – 2002 in the state of Louisiana at -81.9 ft/yr with a range of -88.9/-72.9 ft/yr (Figure D.3- 9; Table D.3-5). Between 1988 and 2002, the short-term rate of erosion at Raccoon Spit slowed to -20.5 ft/yr with a range of -52.3/-2.8 ft/yr (Figure D.3- 10). Table D.3-5 shows that the erosion rates at Raccoon Spit are historically high and significantly decreased in the last period of record. Material dredged from Belle Pass in recent years has been beneficially used along this shoreline, which accounts for a reduction in the erosion rates here.

Reach 22. Caminada – Moreau Coast

The Caminada–Moreau coast is the largest erosional headland in coastal Louisiana (Penland et al. 1986). This coast stretches from Belle Pass east for 8.0 miles to Elmer's Island at Caminada Pass (Figure D.3- 19). Bayou Thunder divides this coast between Lafourche (west) and Jefferson (east) Parishes. Longshore sediment bifurcates at the position of old Pass Fourchon and the point where LA Highway 3090 enters the beach and moves east and west (Harper 1977; Penland and Ritchie 1979). West of Bay Champagne, the shoreline is sandy with continuous dunes. Westward moving material is intercepted by the barge breakwaters and the east jetty of Belle Pass. East of Bay Champagne, sediment is transported to Elmer's Island and further east to Grand Isle. At the end of LA Highway 3090, dredge material has been placed to build a protective barrier with a geotextile revetment. A series of deteriorating abandoned barge breakwaters lies offshore to protect this beach. Since the extension of the Belle Pass jetties in the 1960s, this area has been trapping westward moving sediment, and the rate of erosion has dramatically decreased (Ritchie et al. 1995). Hurricane Lili in 2002 caused extensive erosion of this beach, exposing pipelines and older coastal structures. These man-made structures were quickly buried by post-storm beach recovery processes from sediment arriving from the east and being trapped by the Belle Pass jetties. Off road vehicle traffic that leaves the beach is causing severe damage to the natural and man made dunes. To the east of LA Highway 3090 where vehicular traffic is limited, the natural sand dunes have rebounded from low damaged dunes with vehicular tracks to robust dunes over 4-6 ft in elevation with lush vegetation. To the east, the erosional pressure increases, and sandy beaches with dunes transition to sandy-perched beaches with washover terraces and flats at Bayou Moreau. Eastward, the erosional trend diminishes and wide beaches with continuous dunes develop. The long-term rate of erosion was -41.4 ft/yr between 1887 and 2002 (Figure D.3- 9; Table D.3-5). Between 1988–2002, short-term rates of erosion slowed to -8.6 ft/yr, with a range of -27.1/+10.9 ft/yr (Figure D.3- 10; Table D.3-5). Between 1887–2002, the rate of long-term erosion for this coast has ranged between -51.9 ft/yr to the current low of -8.6 ft/yr. It appears the updrift accretion on the east side of Belle Pass jetties is shifting eastward. An erosional shadow exists to the east of the segmented barge breakwaters, threatening the integrity of the Bay Champagne barrier beach.

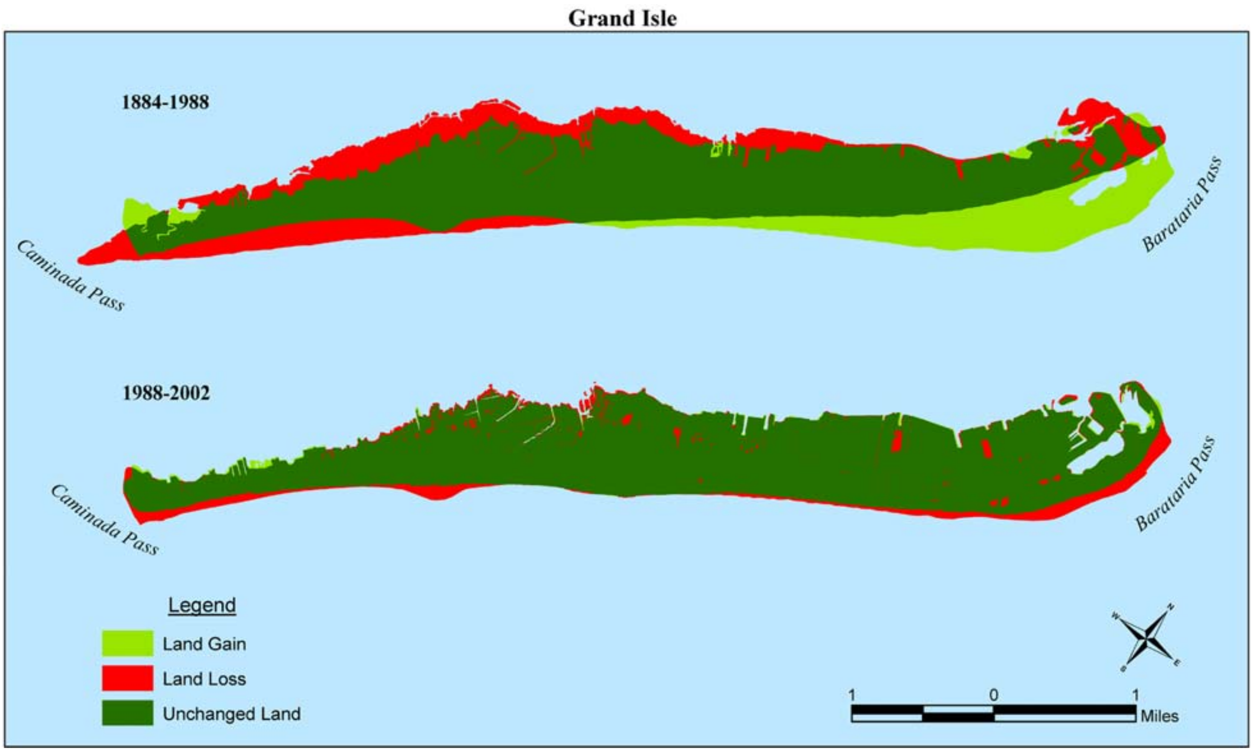


Shoreline Reaches 21) Raccoon Spit and 22) Caminada – Moreau coasts are found here. Note the position of Belle Pass and the large coastal bays truncated by erosion at Bay Marchand and Bay Champagne (Figure D.3-s 9 and 10).

Figure D.3- 19. Historical and modern map overlays for the Caminada-Moreau Coast from 1887 - 1988 and 1988 – 2002.

Reach 23. Grand Isle

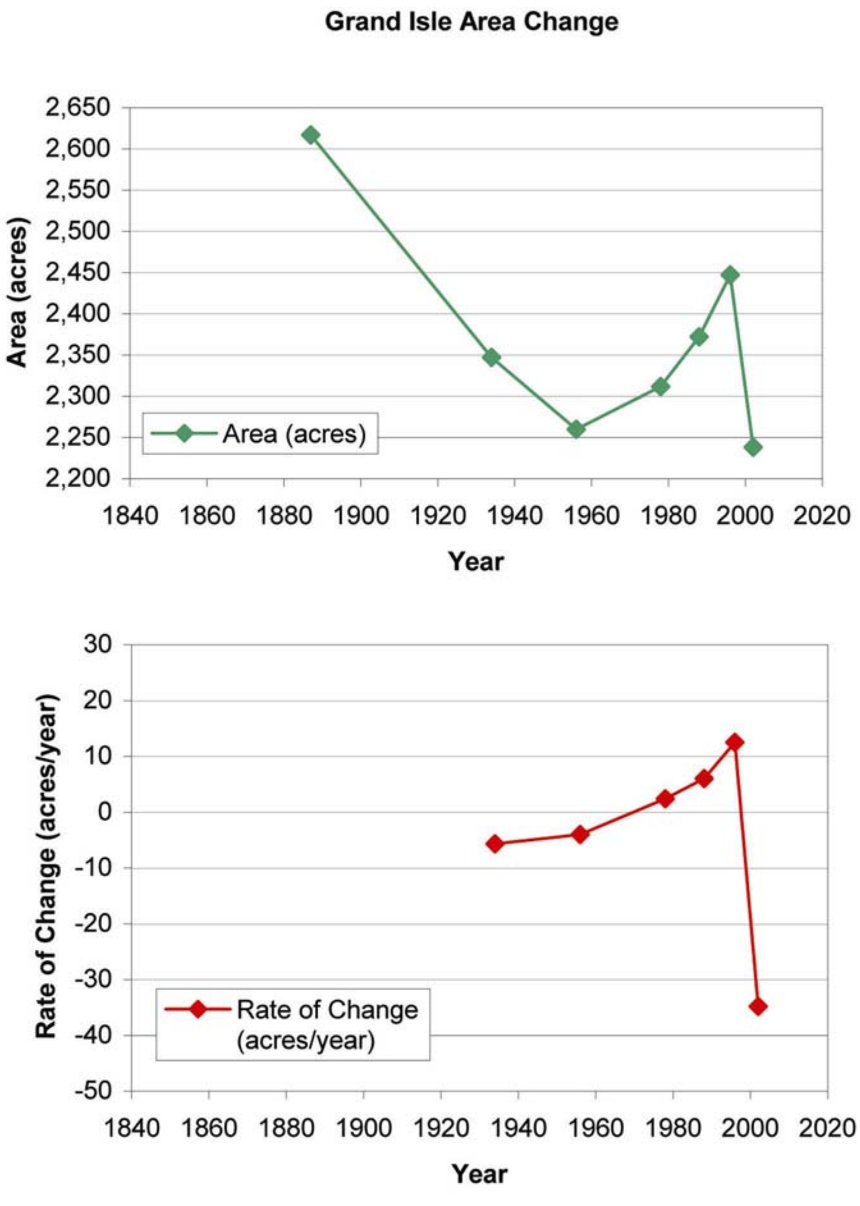
Louisiana's barrier island crown jewel, Grand Isle is the recreational mecca and residential capitol of the coast (Figure D.3- 20). Major oil and gas activities are supported from Grand Isle, and numerous large pipelines make landfall here before moving inland. Between 1884 and 2002, the average rate of shoreline change rate was measured at +2.0 ft/yr, with a range of -8.1/+146 ft/yr (Figure D.3- 9; Table D.3-5). This land gain at Grand Isle is a function of man's activities to protect and stabilize the shoreline. The average shoreline change rate for 1956 – 1978 was +8.4 ft/yr and +17.0 ft/yr for 1978 – 1988, respectively (Table D.3-5). During this period of time, timber groins were built that were ineffective, and created downdrift erosion problems (Theis 1969). The Barataria Pass jetty was built in 1959 and extended in 1964, trapping in excess of 200,000 yd3 per year of eastward littoral drift (U.S. Army Corps of Engineers 1980). As a result, updrift of the jetty, the rates of shoreline advance was in excess of >30 ft/yr. In 1972, the Caminada Pass jetty was built and filled with sediment. The Grand Isle beaches were nourished five times between 1954 and 1988, with more than 4,350,000 yd3 of hydraulic fill (USACE 1980; Mossa et al. 1985). After the USACE beach erosion and hurricane protection was completed in 1985, the shoreline underwent a period of adjustment to the post-construction nearshore slopes and fill configuration. One of the borrow areas for material to construct this project was located in the nearshore of Grand Isle too close to the beach. As a result, the incoming waves were modified such that two “tombolo like” protuberances built out seaward separated by zones of erosion. Eastward from this area extended an erosional shadow downdrift, which damaged this beach nourishment project and hurricane levee. In 1990 in response to this erosional shadow, a hard structure of riprap in the form of two groins with three small breakwaters connected by a seawall was built. The project exacerbated the problem of the erosional shadow, pushing it further east. Over the last decade, a series of 36-segmented breakwaters have been built to correct the problems of this erosional shadow created by the borrow area. The result has been to push this zone of erosion to the east end of Grand Isle adjacent to Barataria Pass. Between 1988 and 2002, the Gulf shoreline of Grand Isle has eroded an average of -14.9 ft/yr with a range of -73.2/-3.7 ft/yr (Figure D.3- 10; Table D.3-5). The hurricanes of 1992/2002 contributed to Grand Isle’s erosion, but the pattern of shoreline retreat indicates the majority of land loss is a result of this coastal structure and the segmented breakwaters built to chase the erosional shadow toward the east.



Note the west end erosion and east end accretion for the period 1884 – 1988. Between 1988-2002 the general trend is erosion for the entire shoreline of Grand Isle (Figure D.3-s 9 and 10).

Figure D.3- 20. Historical and modern map overlays for Grand Isle from 1887 – 2002. Grand Isle is Shoreline Reach 23.

The long-term area rate change of Grande Isle was -33 ac/yr between 1887 and 2002 (Table D.3-15). Prior to 1960, the area loss rate ranged -4.0 to -5.7 ac/yr (Figure D.3- 21) for Grand Isle, and by 1978 the loss rate switched to +2.4 ac/yr (Figure D.3- 16). The rate of area gain continued at Grande Isle and reached +6.0 ac/yr by 1988 and +12.5 ac/yr by 1996. Between 1996 and 2002, Grand Isle began to lose land at -33.5 ac/yr. The loss occurred on the west end of Grande Isle, landward of the USACE dredge borrow site, and downdrift within the segmented breakwater put in place to control the erosional shadow of the rock project. The 2002 hurricanes complicated the erosion problem at Grande Isle. The storms caused portions of the hurricane protection levee to fail within the erosional shadow of the mayor's rock project and the breakwaters built to mitigate the damage of this project. The recent trend in accelerated area loss rate indicates that long-term stability extends beyond 2600, but the short-term indicates the island is at risk of disappearance by 2069 as a result of the recent 1992/ 2002 hurricane and the lack of a substantial nourishment and hurricane levee maintenance event. The rock project and the downdrift breakwaters should be removed to restore the natural movement of sand.

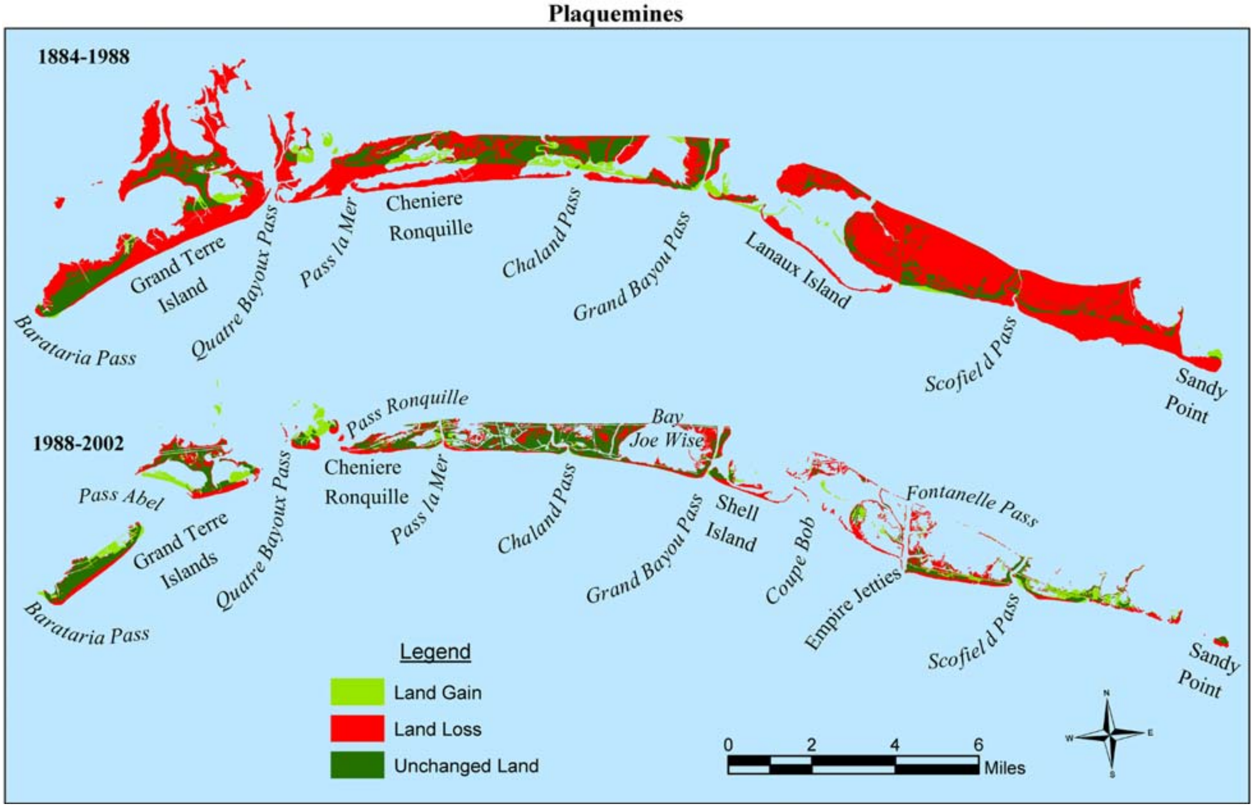


. Note the area of Grand Isle decreased from 2616 ac in 1887 to 2260 ac in 1956. By 1996, a combination of multiple beach nourishment projects and a terminal jetty at Barataria resulted in Grand Isle increasing to 2447 ac of area at +12.5 ac/yr.

Figure D.3- 21. Graphs of the historical area of Grand Isle between 1887 and 2002 with the area rate of change

Plaquemines Barrier Shoreline

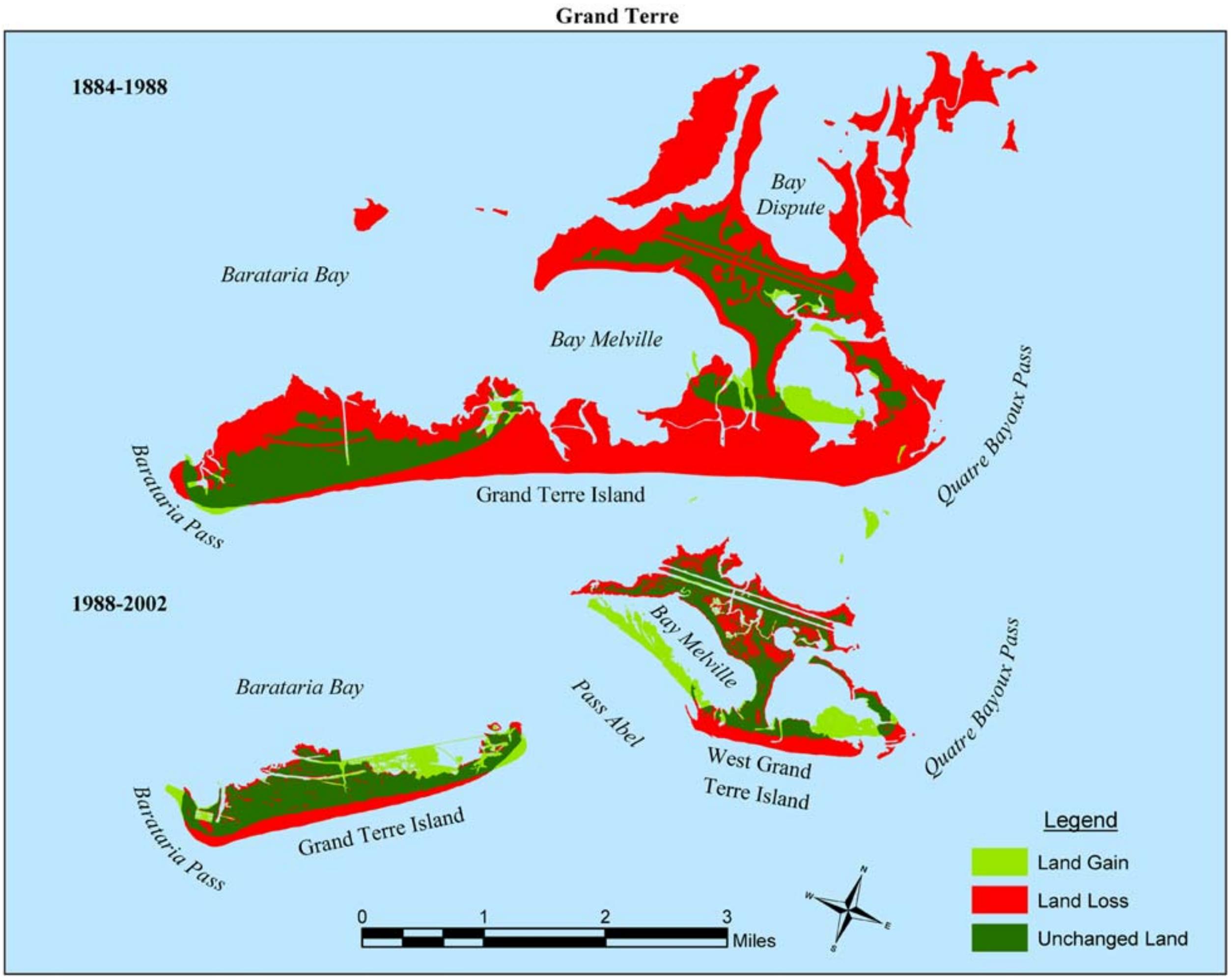
The Plaquemines barrier shoreline stretches from West Grand Terre Island 24.9 miles to the southeast to Sandy Point (Figure D.3- 22). A total of five Shoreline Reaches make up the Plaquemine barrier shoreline. These include (24) West Grand Terre Island, (25) East Grand Terre Island, (26) Cheniere Ronquille, (27) Shell Island, and (28) Scofield (Figure D.3- 9). All of these reaches are in Plaquemines Parish except West Grand Terre Island, which lies in Jefferson Parish. The Plaquemines barrier shoreline is diverse in coastal geomorphic features, including the remnants of two large barrier islands of the 1880s: Grand Terre Island and Shell Island (Ritchie et al. 1990). Many different processes affect this area, however, extensive oil and gas development has left a strong imprint on this area. Numerous pipeline and access canals with dredge spoil banks are common. Major tidal channels include Barataria Pass, Pass Abel, Quatre Bayou Pass, Pass Ronquille; Pass le Mar, Chaland Pass, Grand Bayou Pass, Coupe Bob Pass, Empire Pass, and Scofield Bayou. The Empire Pass jetties are a major commercial waterway connecting Empire with the Gulf. Longshore sediment moves southeast to northwest along this shoreline. At the Empire Pass jetties, an erosional shadow extends to the northwest, detrimentally impacting Shell Island.



The Plaquemines barrier shoreline is comprised of Shoreline Reaches 24) west Grand Terre, 25) East Grand Terre Island, 26) Cheniere Ronquille, 27) Shell Island and 28) Scofield. The long-term average rates of shoreline erosion here is -23.1 ft/yr for 1884 – 2002 and the rate has accelerated to -42.3 ft/yr for 1988 – 2002 (Figure D.3-s 9 and 10).

Figure D.3- 22. Historical and modern map overlays for the Plaquemine barrier shoreline between 1884 – 12988 and 1988 – 2002.

The long-term average erosion rates for the Plaquemines barrier shoreline were -23.1 ft/yr with a range of -69.8/+9.0 ft/yr between 1884 and 2002 (Table D.3-6). Between 1988 and 2002, the average short-term rate of erosion was -42.3 ft/yr with a range of -101.5/-17.2 ft/yr. This acceleration involves a complicated series of natural processes and man's interactions. Extensive oil and gas development has occurred here with canals being dredged and pipelines constructed, all of which altered the natural hydrology of the backbarrier area (Penland et al. 2000 a,b). Fontellene Pass is a major navigation channel for Empire and a major jetty system was built there, dramatically disrupting the sediment supply to Shell Island.



In 1884, Grand Terre Island was a single undivided island. Between 1884 and 1934, Grand Terre Island was breached and Pass Abel formed creating West and East Grand Terre Islands (Figure D.3-s 9 and 10)

Figure D.3- 23. Historical and modern map overlays for the West and East Grand Terre Islands between 1884-1988 and 1988-2002..

Grand Terre Island was a single island in 1884, and today it consists of two Shoreline Reaches, 24 and 25, representing West Grand Terre Island and East Grand Terre Islands (Figure D.3- 23). In 1884, the single island of Grand Terre Island measured 4,197 acres (Figure D.3- 24 and Table D.3-16). By 1934, Pass Abel has formed, separating West and East Grand Terre with a total area of 2,614 or a decrease of 388 ac. Between 1932 and 2002, the rate of area decrease ranged from -16.2 ac/yr to -26.9 ac/yr. McBride et al. (1992) predicted that the long-term (1884–1988) disappearance date was 2033 and the short-term (1973–1988) date was 2036. The new long-term (1884–2002) disappearance data for Grande Terre Island is 2043, and the short-term (1988– 2002) date remains the same.

Reach 24. West Grand Terre Island

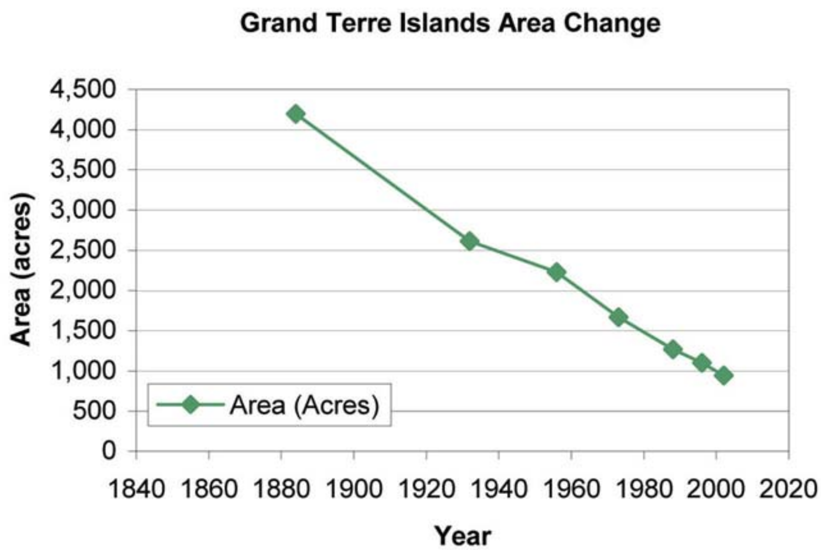
Shoreline Reach 24 is 2.2 miles length and consists of west Grand Terre Island lying in Jefferson Parish (Figure D.3- 23). Habitation on the western end of the original single island of Grand Terre Island dates back to 1884 when this island was home to the infamous pirate Jean Lafitte. By 1934, the original single island of Grand Terre had been breached, and Pass Abel had formed. The Andoza sugarcane plantation was located here in the late 1700s. Today, historic Fort Livingston is adjacent to Barataria Pass and immediately to the east of the LA Department of Wildlife and Fisheries Marine Laboratory. The USACE beneficially used navigation maintenance dredge material from Barataria Pass waterway to create backbarrier marsh and other barrier island habitats here. The CWPPRA program has also conducted vegetative plantings at west Grande Terre. Oil and gas facilities are found throughout the island. Continuous dunes with a sandy beach front Fort Livingston reflecting the low rates of shoreline change and the sediment availability there. To the east, the relief of the shoreline decreases to a low washover terrace as the erosional conditions increase. The long-term average rate of Gulf shoreline change is -7.7 ft/yr between 1884 and 2002, with a range of -16.1/-2.2 ft/yr (Figure D.3- 9; Table D.3-5). Gulf shoreline erosion accelerated to -21.7 ft/yr with a range of -44.3/+20.3 ft/yr between 1988 and 2002.

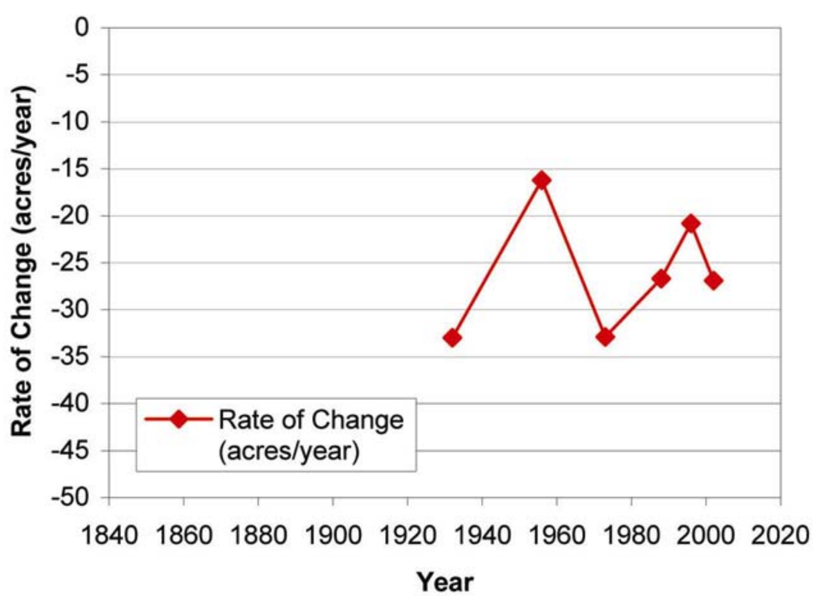
Reach 25. East Grand Terre Island

Located on the opposite side of Pass Abel from West Grand Terre Island, East Grand Terre Island is 2.8 miles long within Plaquemines Parish (Figure D.3- 23; Table D.3-4). Prior to the formation of Pass Abel, sometime before 1934, East Grand Terre Island was part of the single island of Grand Terre in the 1880s. Today, east Grand Terre Island is mostly a remnant of mainland marsh with a perched beach along the Gulf shoreline (Ritchie et al. 1990). An erosional marsh platform outcrops in the surf zone, and erosion has reduced this shoreline to a low sandy washover terrace or flat. Oil and gas structures are the only man-made features in this shoreline reach. The long-term erosion rate for East Grand Terre Island between 1884 and 2002 was -38.0 ft/yr with a range of -69.8/-24.9 ft/yr (Figure D.3- 9; Table D.3-5). The 1988–2002 short-term erosion rate accelerated to -50.1 ft/yr and ranged from -62.3/+258.8 ft/yr. A combination of tidal inlet widening at Pass Abel and Quatre Bayou Pass on the flanks of east Grand Terre and the 1992/2002 hurricanes are driving the high rates of erosion here.

Reach 26. Cheniere Ronquille

Cheniere Ronquille is located on the western margin of the Plaquemines barrier shoreline (Figure D.3- 22). Lying between Pass Ronquille and Grand Bayou Pass, Shoreline Reach 26 is 8.7 miles long in Plaquemines Parish (Table D.3-4). Cheniere Ronquille has extensive oil and gas development long ts entire length in the form of pipeline right-of-ways and access canals. Dredge spoil banks along the margins of the man-made features form topographic highs supporting small shrubs and trees that are truncated by the eroding shoreline. Perched beaches of sand and shell with backshore washover terraces and flats are located between the vegetated dredge spoil banks (Ritchie et al. 1990). Pass La Mar and Chaland Pass are large natural tidal inlets that connect the inland estuaries waterbodies and wetlands with the Gulf of Mexico. The long-term erosion rate between 1884 and 2002 was -19.7 ft/yr (Figure D.3- 9; Table D.3-5). The 1988–2002 short-term erosion rate remained high at -17.2 ft/yr with a greater short-term variability of -109.1/+8.3 ft/yr than 1884–2002 (Figure D.3- 10; Table D.3-5).



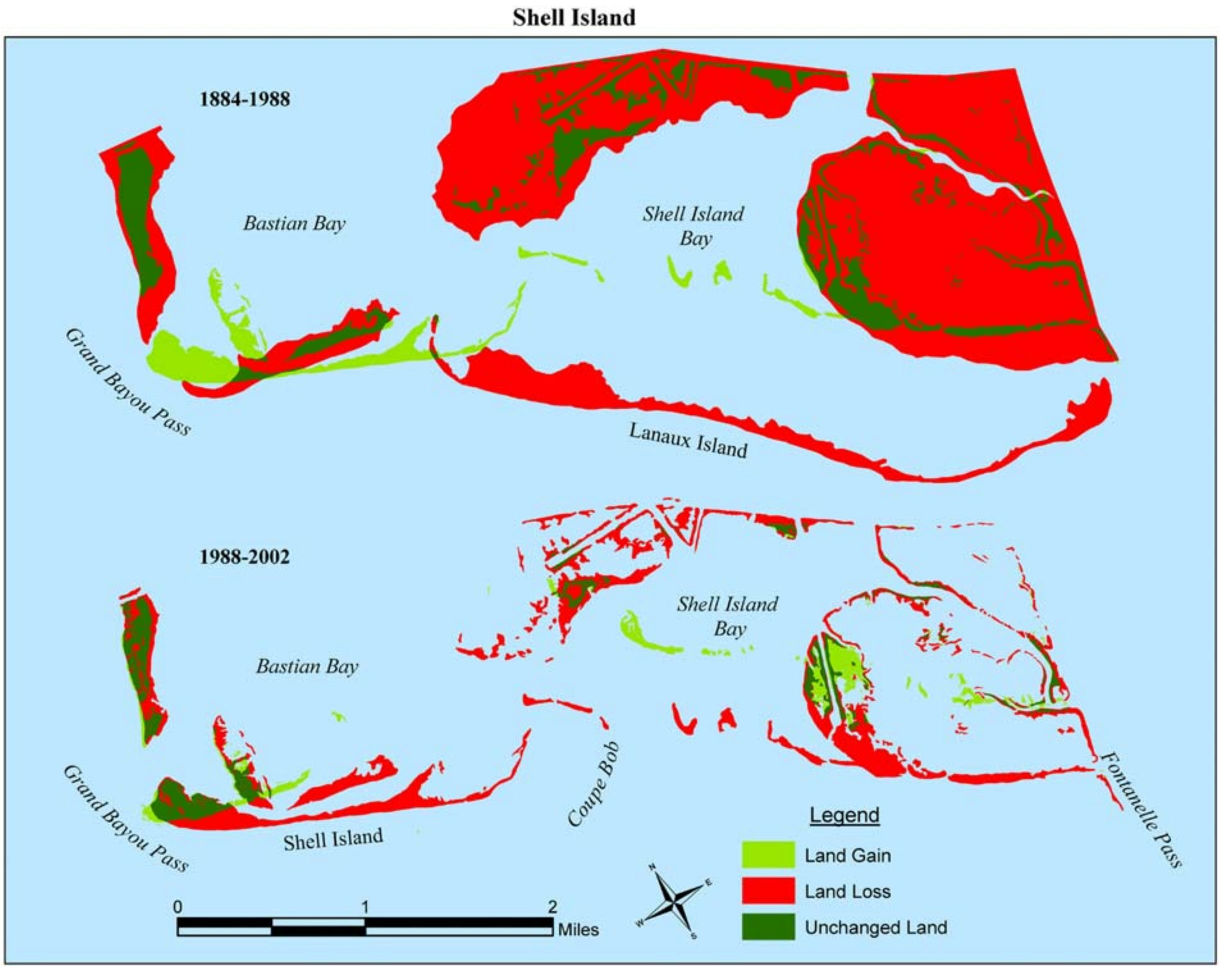


Note: by 1934, Pass Abel had formed creating West and East Grand Terre Islands. Since 1934, West and East Grand Terre Island has steadily decreased in area from -33 ac/yr for 1887-1934 to -26.9 ac/yr for 1996-2002.

Figure D.3- 24. Graphs of the historical area of Grand Terre between 1884 and 2002

Reach 27. Shell Island

Shoreline Reach 27 is Shell Island in Plaquemines Parish, which is 2.3 miles long (Table D.3-4). Shell Island gets its name from its composition of almost 100% oyster shells (Ritchie et al. 1990). Shell Island is located between Grand Bayou Pass and Fontellene Pass (Figure D.3- 22 and 26). Between 1973 and 1988, Hurricane Bob (1978) breached Shell Island with the eastern half welding onto the Fontenelle Pass shoreline and the western half enclosed by Bastian Bay. By 2002, only the erosional remnants of Shell Island could be found in the eastern end of Shell Island Bay.



Shell Island is located on the downdrift side of the Empire Jetties. The jetties are producing an erosional shadow that is disrupting the sediment supply to Shell Island.

Figure D.3- 25. Historical and modern map overlays for Shell Island along the Plaquemine shoreline between 1884 – 1988 and 1988 – 2002.

The long-term average rate of erosion for Shell Island between 1884 and 2002 was -38.5 ft/yr with a range of -61.8/-7.0 ft/yr (Table D.3-18). The short-term rate of erosion accelerated to -101.5 ft/yr between 1998 – 2002 with a range of -233.0/+112.2 ft/yr. Shell Island measured 314 ac in 1884 and increased in size at a rate ranging +0.3 -2.5 ac/yr until 1956 (Figure D.3- 25; Table D.3-18). After the Empire jetties were built in the 1950s, the area of Shell Island rapidly diminished. McBride et al. (1992) predicted that Shell Island would disappear between 2002 and

2103. New LCA information predicts the short-term disappearance date as 2009 and the long-term date as 2027.

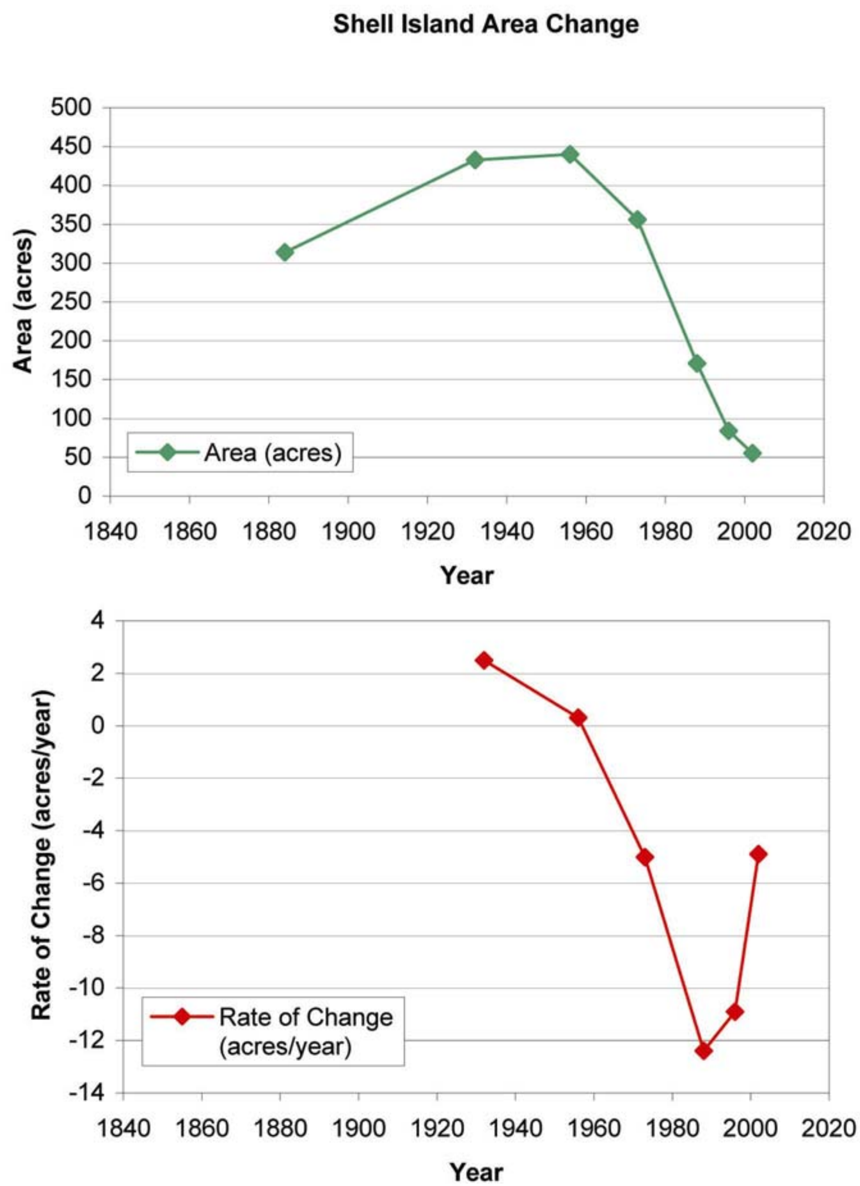


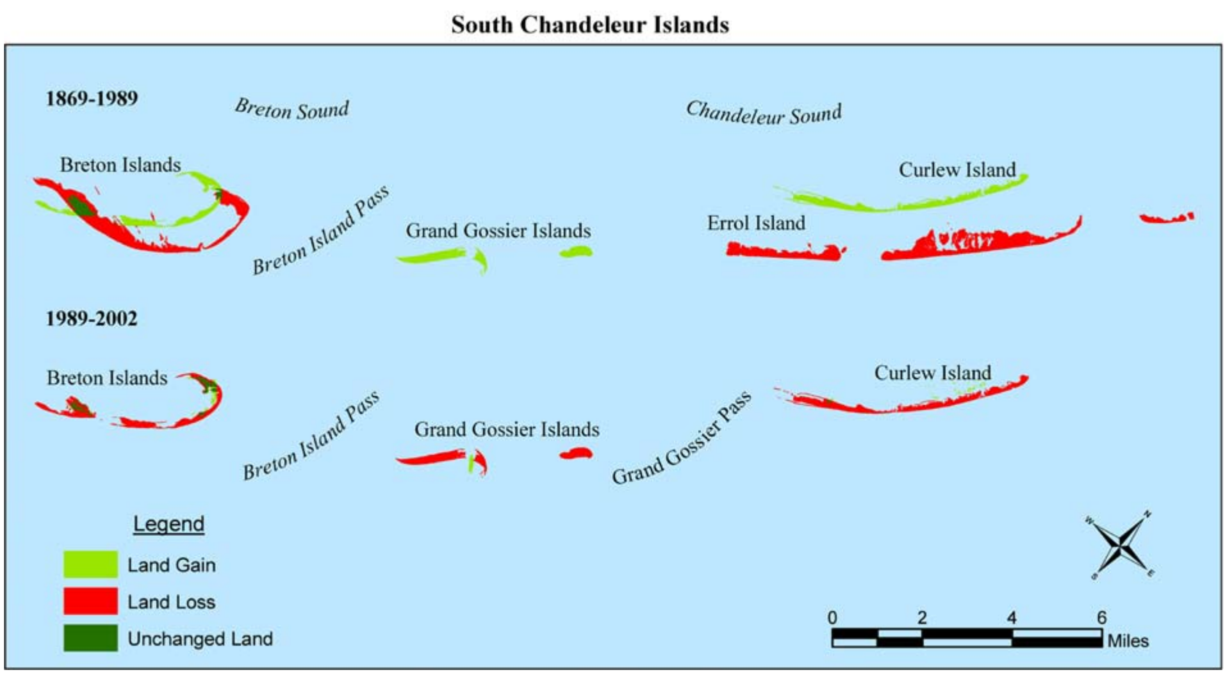
Figure D.3- 26. Graphs of the historical area of Shell Island between 1884 and 2002. Shell Island has a long-term area loss rate of –2.2 ac/yr and a short-term loss rate of -8.3 ac/yr.

Reach 28. Scofield

The Scofield Shoreline Reach stretches 10.2 miles from the Empire Jetties at Pass Fontunelle east to Sandy Point in Plaquemines Parish (Table D.3-4). The morphology of this shoreline is low, with a discontinuous sandy shell beach, which is perched in many areas with marsh outcroppings (Ritchie et al. 1990). Washover terraces and flats are the common morphologic features. Oil and gas pipelines parallel the shoreline, and other facilities are found in the backshore. The long-term erosion rate here is -11.6 ft/yr with a range of -32.4/+0.6 ft/yr between 1884 and 2002 (Table D.3-5). The 1988 – 2002 short-term erosion rate almost doubled to -20.9 ft/yr with a range of -93.5/ +37.2 ft/yr.

Chandeleur Barrier Shoreline

The premier barrier shoreline in Louisiana and the U.S. Gulf Coast if not America, the Chandeleur Islands form the seaward geologic framework of the largest estuary in the Gulf of Mexico (Suter et al. 1987). From north to south, Chandeleur Island, Curlew Island, Grand Gossier Islands, and Breton Islands make up the Chandeleur Islands barrier shoreline backed by Chandeleur Sound and Breton Sound (Penland et al. 1985). This shoreline is 58.2 miles long, (Table D.3-4). Stretching from Plaquemines Parish to St. Bernard Parish, the Chandeleur Island shoreline consists of shoreline reaches (29) Breton Island, (30) Grand Gossier and Curlew Islands, and (31) Chandeleur Island. This area was designated as the Breton Island National Wildlife Area by the U.S. Fish and Wildlife Service and specifically, Chandeleur Island proper has been declared a Wilderness Area. The Chandeleur Island barrier shoreline is known for superlatives: largest sea grass meadows, largest marine and shorebird rookeries, world reknown geomorphology, fabulous fishing, and the first defense line for New Orleans against hurricanes (Ritchie et al. 1992).



The long-term and short-term rates for Breton Island and Grand Gossier-Curlew Islands was -20.9/-62.8 ft/yr to -48.1/-126.5 ft/yr. Note the dramatic pattern of shifting combined with disappearance and reappearance

Figure D.3- 27. Historical and modern map overlays of the Southern Chandeleur Islands consisting of Breton, Grand Gossier, and Curlew Islands between 1869 and 2002.

The long-term average rates of gulf shoreline erosion along the entire Chandeleur Island barrier shoreline were -44.5 ft/yr with a range of -62.81/ +11.2 ft/yr for the period of 1855–2002

(Table D.3-6). Recently, the 1988–2002 average rate of shoreline erosion accelerated to -69.3 ft/yr ranging -126.5/-45.7 ft/yr. Over the last 147 years, the Chandeleur Islands have decreased in area (Figure D.3-s 27, 28, and 29). This long-term area decrease has been punctuated by periods of land loss and gain (Figure D.3- 29, Table D.3-19). The average long-term rate of area loss was -47.7 ac/yr between 1855 and 2002. The short-term rates of area decrease were -256.0 ac/yr. Two periods of land gain have occurred in the Chandeleur Islands: one between 1922 and 1951 and the other between 1969 and 1989. The overall land change for the Chandeleur Islands is a decrease in size. McBride et al. (1992) predicted the long-term (1855 – 1989) and the short-term (1978–1989) disappearance dates of the Chandeleur Islands as 2209 and 2300 respectively. Information current to this LCA study indicates that the new predicted long-term and short-term disappearance dates are 2046 and 2011.

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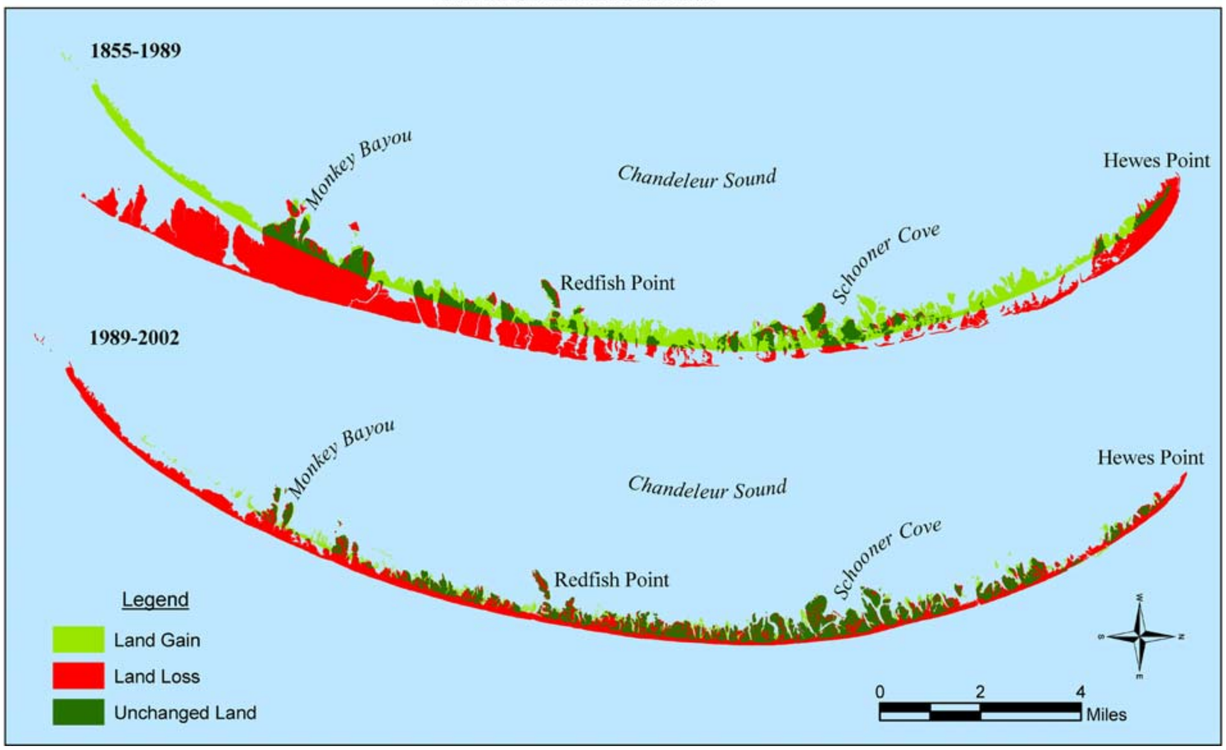


This diagram represents Shoreline Reach 31 in St. Bernard Parish. The long-term and short-term average rate of gulfside erosion is -18.6 ft/yr and -45.7 ft/yr. Note the trend of rapid erosion along the southern end of this island near Monkey Bayou and a decrease towards the north inthe direction of Hewes Point (Figure D.3-s 9 and 10).

Figure D.3- 28. Historical and modern map overlays for North Chandeleur Island dated 1855 and 1988.

Reach 29. Breton Island

Shoreline Reach 29 is Breton Island in Plaquemines Parish just south of the Mississippi River Gulf Outlet (MRGO). A total of 6.6 miles in length, a shallow ephemeral tidal inlet sometimes separates West Point from North Point at Breton Island, Figure D.3- 27, Table D.3-4). Dune and washover terraces are the dominant landform with washover flats near overwash channels and tidal inlets. The long-term rate of shoreline erosion was -20.9 ft/yr between 1869 and 2002, with a range of -31.1/-4.0 ft/yr (Figure D.3- 9; Table D.3-5). Between 1989 and 2002, the short-term rate of erosion was -48.1 ft/yr with a range of -72.4/-26.5 ft/yr (Figure D.3- 10; Table D.3-5).

Reach 30. Grand Gossier/Curlew Islands

The Grand Gossier and Curlew Islands Shoreline Reach 30 lie in both Plaquemines Parish and St. Bernard Parish and are 17.1 miles in length (Figure D.3- 4). The long-term average erosion rate between 1869 and 2002 was -62.8 ft/yr with a range of -135.5/+22.7 ft/yr (Figure D.3- 9; Table D.3-5). The short-term average shoreline erosion rates were higher between 1989 and 2002 at -126.5 ft/yr, and the range is -199.4/-20.4 ft/yr (Figure D.3- 10; Table D.3-5). These high rates of shoreline erosion preclude any significant dune development and as a consequence, the dominant landforms of the Grand Gossier and Curlew Islands are washover flats and overwash channels.

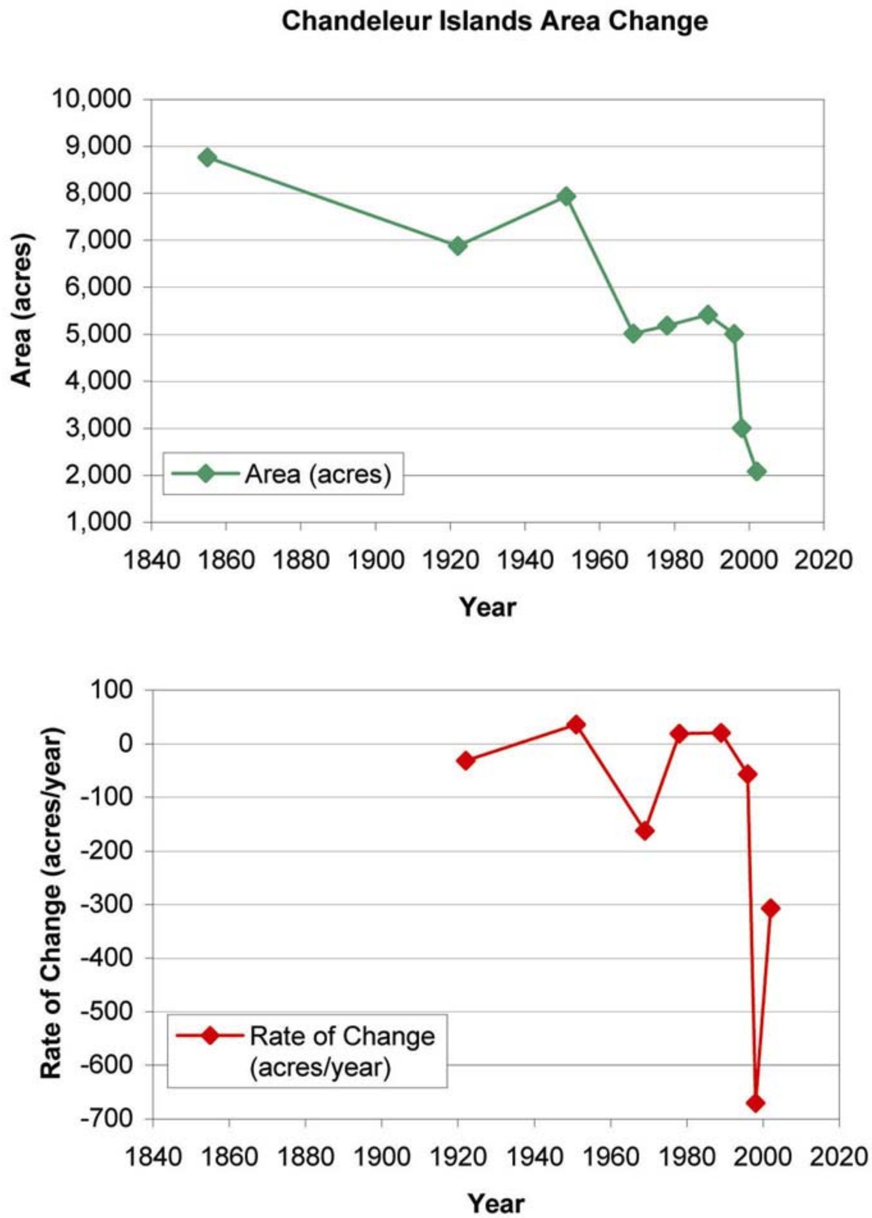
Reach 31. North Chandeleur Island

North Chandeleur Island is the most beautiful and ecologically unique of Louisiana's 10 barrier islands. Shoreline Reach 31, 30.7 miles long, contains north Chandeleur Island and lies entirely in St. Bernard Parish. From south to north, the rates of shoreline erosion decrease, and this decrease is reflected in the island geomorphology (Figure D.3- 28). The southern beaches near Monkey Bayou are more shell than sand, are often perched, and dominated by washover flats (Ritchie et al. 1992). Northward, the erosion rates decrease and the sediment availability increases. Sand dunes begin to develop northward and reach the highest elevations in Louisiana at 10-15 ft between Schooner Cove and Hewes Point (Figure D.3- 29). The long-term rate of shoreline erosion is -18.6 ft/yr, and the range was -57.6/+11.2 ft/yr for the period 1855–2002. Since 1989– 2002, the short-term average shoreline erosion rate was -45.7 ft/yr and ranged between -226.4/+16.3 ft/yr.

3.5 Conclusion

The Gulf of Mexico shoreline of Louisiana is experiencing a net loss of land. The average rate of shoreline erosion between 1855 and 2002 was 19.9 ft/yr. Since 1988, the rates of Gulf shoreline erosion have accelerated to -30.9 ft/yr. The natural Mississippi River building process have been altered so dramatically that Louisiana is experiencing the highest rates of shoreline erosion in the United States. The muddy sediments that make up the coast, rapid rates of subsidence, and frequent hurricanes all collectively contribute to these high erosion rates. Shoreline erosion was recognized as a serious problem in the 1950s.

The muddy sediments of the Mississippi River that comprise coastal Louisiana are prone to erosion. Because they are fine-grained and soft, waves easily erode these deposits and redistribute the sands into barrier beaches, bars, spits, and islands. Where man has built coastal structures that disrupt the natural redistribution of the reworked sands, zones of accelerated erosion have developed. There are isolated areas of accretion in the vicinity of some coastal structures, but the area of gain is small compared to the area of loss. In addition, there is localized progradation associated with the Mississippi and Atchafalaya Rivers, but the area of shoreline retreat is several orders of magnitude larger than the area of shoreline advance. Man has attempted to control the erosion on Louisiana's Gulf shoreline with a variety of engineered structures. Seawalls, breakwaters, and groins have met with limited or no success in holding back the Gulf of Mexico. The most successful erosion control and restoration projects to date used sediment and vegetation engineered to work in concert with the natural processes shaping the evolution of our coast. The sustainability of coastal Louisiana depends on our ability to find solutions that are compatible with nature. Sediment and vegetation are the proven materials for scientists and engineers to use in the restoration of coastal Louisiana.



The area of the Chandeleur Islands decreased from 8761 ac in 1855 to 2082 ac in 2002. The long-term rate of area loss is -47.7 ac/yr. The fluctuation on the area and rates of area change are related to periods of storm impact.

Figure D.3- 29. Graph of the historical area of the Chandeleur Islands between Breton Island and Hewes Point.